REVISED EDITION.

THE

GEOGRAPHY OF THE HEAVENS,

AND

CLASS-BOOK OF ASTRONOMY:

ACCOMPANIED BY

A CELESTIAL ATLAS

BY ELIJAH H. BURRITT, A. M.

A NEW EDITION,

REVISED AND ILLUSTRATED.

BY HIRAM MATTISON,

PROFESSOR OF NATURAL PHILOSOPHY AND ASTRONOMY IN THE FALLEY SEMINARY; AUTHOR OF THE PRIMARY ASTRONOMY, ELEMENTARY ASTRONOMY, ASTRONOMICAL MAPS, ETC., ETC

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PUBLISHERS' NOTICE.

In presenting a new edition of this work to the public, it is proper to point out several very important improvements which have been made.

The work has been thoroughly revised, from beginning to end, by one of the most competent Astronomers in the country. In this revision all errors and discrepancies between the book and the Atlas have been corrected, and the work brought down to the present improved state of the science, by the incorporation of all recent discoveries.

The *Atlas* also has been improved by the addition of several new figures, and the correction of numerous errors; so that the work as a whole may not only be regarded as eminently *full* and *complete*, but as in the highest degree *accurate*.

In the second part of the work great improvements have been made in the number and quality of the illustrations. Not only have most of the old ones been re-engraved and improved, but the work has been enriched by the addition of about *fifty new cuts*. This of itself will materially enhance the value of the book.

In the prosecution of his labors the Editor has availed himself of the correspondence of several eminent Teachers and Scholars, among whom are Dr. Dick, of Scotland, Mr. L. A. Miller of Woodstock, Vt.; and W. H. Wells, M. A., of Newburyport, Mass. The communications of these gentlemen, especially, have done much to facilitate the work of revision, and have contributed not a little to the present accuracy and completeness of the book.

That the letter-press of the book might correspond with the improvements in the text, and the new and beautiful illustrations, the whole has been re-stereotyped and now appears in a dress worthy of its character, as a well-known, popular and standard work. We commend it to teachers as more than ever entitled to their confidence and patronage.

PREFACE.

I HAVE long felt the want of a Class Book, which should be to the starry heavens, what Geography is to the earth; a work that should exhibit, by means of appropriate delineations, the scenery of the heavens: the various constellations arranged in their order, point out and classify the principal stars, according to their magnitudes and places, and be accompanied, at the same time, with such familiar exercises and illustrations, adapted to recitation, as should bring it within the pale of popular instruction, and the scope of juvenile understandings.

Such a work I have attempted to supply. I have endeavored to make the descriptions of the stars so familiar, and the instructions for finding them so plain, that the most inexperienced should not fail to understand them. In accomplishing this, I have relied but little upon globes and maps, or books. I very early discovered that it was an easy matter to sit down by a celestial globe, and, by means of an approved catalogue, and the help of a little graduated slip of brass, make out, in detail, a minute description of the stars, and discourse quite familiarly of their position, magnitude and arrangement, and that when all this was done, I had indeed given the pupil a few additional facilities for finding those stars upon the artificial globe, but which left him, after all, about as ignorant of their apparent situation in the heavens, as before. I came, at length, to the conclusion, that any description of the stars, to be practically useful, must be made from a careful observation of the stars themselves, and made at the time of observation.

To be convinced of this, let any person sit down to a celestial globe or map, and from this alone, make out a set of instructions in regard to some favorite constellation, and then desire his pupil to trace out in the firmament, by means of it, the various stars which he has thus described. The pupil will find it little better than a fancy sketch. The bearings and distances, and especially, the comparative brightness, and relative positions, will rarely be exhibited with such accuracy that the young observer will be inspired with much confidence in his guide.

I have demonstrated to *myself* at least, that the most judicious instructions to put on paper for the guide of the young in this study are those which I have used most successfully, while in a clear evening, without any chart but the firmament above, I have pointed out, with my finger, to a group of listeners, the various stars which compose this and that constellation.

In this way, the teacher will describe the stars as they actually appear to the pupil—taking advantage of those obvious and more striking features that serve to identify and to distinguish them from all others. Now if these verbal instructions be committed to writing and placed in the hands of any other pupil, they will answer nearly the same end. This is the method which I have pursued in this work. The descriptive part of it, at least, was not composed by the light of the sun, principally, nor of a lamp, but by the light of the stars themselves. Having fixed upon the most conspicuous star, or group of stars, in each constellation, as it passed the meridian, and with a pencil carefully noted all the identifying circumstances of position, bearing, brightness, number and distance—their geometrical allocation, if any, and such other descriptive features as seemed most worthy of notice, I then returned to my room to transcribe and classify these memoranda in their proper order; repeating the same observations at different hours the same evening, and on other evenings at various periods, for *a succession of years;* always adding such emendations as subsequent observations matured. To satisfy myself of the applicability of these descriptions, I have given detached portions of them to different pupils, and sent them out to find the stars; and I have generally had the gratification of hearing them report, that "every thing was just as I had described it." If a pupil found any difficulty in recognizing a star, I re-examined the description to see if it could be made better, and when I found it susceptible of improvement, it was made on the spot. It is not pretended, however, that there is not yet much room for improvement; for whoever undertakes to delineate or describe every visible star in the heavens, assumes a task, in the accomplishment of which he may well claim some indulgence.

The maps which accompany the work, in the outlines and arrangement of the constellations, are essentially the same with those of Dr. Wollaston. They are projected upon the same principles as maps of Geegraphy, exhibiting a faithful portraiture of the heavens for every month, and consequently for every day in the year, and do not require to be rectified, for that purpose, like globes.

They are calculated, in a good measure, to supersede the necessity of celestial globes in schools, inasmuch as they present a more natural view of the heavenly bodies, and as nearly all the problems which are peculiar to the celestial globe, and a great number besides, may be solved upon them in a very simple and satisfactory manner. They may be put into the hands of each individual in a class at the same time, but a globe cannot be. The student may conveniently hold them before his eye to guide his survey of the heavens, but a globe he cannot. There is not a conspicuous star in the firmament which a child of ten years may not readily find by their aid. Besides, the maps are always right and ready for use, while the globe is to be rectified and turned to a particular meridian; and then if it be not held in that position for the time being it is liable to be moved by the merest accident or breath of wind.

There is another consideration which renders an artificial globe of very little avail as an auxiliary for acquiring a knowledge of the stars while at school. It is this;—the pupil spends one, perhaps two weeks, in solving the problems, and admiring the figures on it, in which time it has been turned round and round a hundred times; it is then returned safely to its case, and some months afterwards, or it may be the next evening, he directs his eye upwards to recognize his acquaintance among the stars. He may find himself able to recollect the names of the principal stars, and the uncouth forms by which the constellations are pictured out; but which of all the positions he has placed the globe in, is now so present to his mind that he is enabled to identify it with any portion of the visible heavens?

He looks in vain to see

> "Lions and Centaurs, Gorgons, Hydras rise,
> And gods and heroes blaze along the skies."

He finds, in short, that the bare study of the globe is one thing, and that of the heavens quite another; and he arrives at the conclusion, that if he would be profited, both must be studied and compared together. This, since a class is usually furnished with but one globe, is impracticable. In this point of view also, the maps are preferable.

I have endeavored to teach the Geography of the heavens in nearly the same manner as we teach the Geography of the earth. What that does in regard to the history, situation, extent, population and principal cities of the several kingdoms of the earth, I have done in regard to the constellations; and I am persuaded, that a knowledge of the one may be as easily obtained, as of the other. The systems are similar. It is only necessary to change the terms in one, to render them applicable to the other. For this reason, I have yielded to the preference of the publisher in calling this work "Geography of the Heavens," instead of URANOGRAPHY, or some other name more etymologically apposite.

That a serious contemplation of those stupendous works of the Most High, which astronomy unfolds, is calculated above all other departments of human knowledge, to enlarge and invigorate the powers of religious contemplation, and subserve the interests of rational piety, we have the testimony of the most illustrious characters that have adorned our race.

If the work which I now submit, shall have this tendency, I shall not have written in vain. Hitherto, the science of the stars has been but very superficially studied in our schools, for want of proper helps. They have continued to gaze upon the visible heavens without comprehending what they saw. They have cast a vacant eye upon the splendid pages of this vast volume, as children amuse themselves with a book which they are unable to read. They have caught here and there, as it were, a capital letter, or a picture, but they have failed to distinguish those smaller characters on which the sense of the whole depends. Hence, says an English Astronomer, "A comprehensive work on *Descriptive Astronomy*, detailing, in a popular manner, all the facts which have been ascertained respecting the scenery of the heavens, accompanied with a variety of striking delineations, accommodated to the capacity of youth, is a *desideratum*." How far this desirable end is accomplished by the following work, I humbly leave to the public to decide.

Hartford, *Feb.* 1833.

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INTRODUCTION.

ADVANTAGES OF THE STUDY OF ASTRONOMY.

BY

THOMAS DICK, LL. D.

ASTRONOMY is a science which has, in all ages, engaged the attention of the poet, the philosopher, and the divine, and been the subject of their study and admiration. Kings have descended from their thrones to render it homage, and have sometimes enriched it with their labors; and humble shepherds, while watching their flocks by night, have beheld with rapture the blue vault of heaven, with its thousand shining orbs moving in silent grandeur, till the morning star announced the approach of day. The study of this science must have been co-eval with the existence of man. For there is no rational being who, for the first time, has lifted his eyes to the nocturnal sky, and beheld the moon walking in brightness among the planetary orbs and the host of stars, but must have been struck with awe and admiration at the splendid scene, and its sublime movements, and excited to anxious inquiries into the nature, the motions, and the destinations of those far-distant orbs. Compared with the splendor, the amplitude, the august motions, and the ideas of infinity which the celestial vault presents, the most resplendent terrestrial scenes sink into inanity, and appear unworthy of being set in competition with the glories of the sky.

Independently of the *sublimity* of its objects, and the pleasure arising from their contemplation, Astronomy is a study of vast utility, in consequence of its connection with terrestrial arts and sciences, many of which are indebted to the observations, and the principles of this science, for that degree of perfection to which they have attained.

Astronomy has been of immense utility to the science of

GEOGRAPHY;

for it is chiefly in consequence of celestial observations that the *true figure* of the earth has been demonstrated and its *density* ascertained. It was from such observations, made on the mountain *Schehallien* in Scotland, that the attraction of mountains was determined. The observations were made by taking the meridian distances of different fixed stars near the zenith, first on the south, and afterwards on the north side of the hill, when the plumb line of the Sector was found, in both cases, to be deflected from the perpendicular towards the mountain; and, from calculations founded on the quantity of this deflection, the mean density of the earth was ascertained. It was likewise by means of celestial observations that the length of a degree of the meridian was measured, and the circumference of the globe, with all its other dimensions, accurately ascertained; for, to ascertain the number of degrees between any two parallels on the Earth's surface, observations must be taken, with proper instruments, of the sun or of the stars, at different stations; and the accurate measurement of the terrestrial distance between any two stations or parallels, partly depends on astronomical observations combined with the principles and operations of Trigonometry. So that without the aids of this science, the figure and density, the circumference and diameter of our terrestrial habitation, and the relative position of places on its surface, could never have been ascertained.

Astronomy is likewise of great utility to the art of

NAVIGATION;

without a certain knowledge of which the mariner could never have traced his course through pathless oceans to remote regions —the globe would never have been circumnavigated, nor an intercourse opened between the inhabitants of distant lands. It is of essential importance to the navigator, not only to know the situation of the port to which he is bound, but also to ascertain with precision, on what particular portion of the terraqueous globe he is at any time placed—what course he is pursuing—how far he has traveled from the port at which he embarked—what dangerous rocks or shoals lie near the line of his course—and in what direction he must steer, in order to arrive, by the speediest and the safest course, to his destined haven. It is only, or chiefly, by astronomical observations that such particulars can be determined. By accurately observing the distance between the moon and certain stars, at a particular time, he can calculate his distance East or West from a given meridian; and, by taking the meridian altitude of the sun or of a star, he can learn his distance from the Equator or from the poles of the world. In such observations, a knowledge of the constellations, of the pole-star, and of the general positions of all the stars of the first and second magnitude, is of particular importance; and, therefore, a navigator who is unacquainted with the science of the heavens, ought never to be appointed to conduct a ship through the Indian, the Atlantic, or the Pacific oceans, or through any portions of the sea which are not within sight of land. By the observations founded on astronomical science, which have been made in different regions by mariners and travelers of various descriptions, the latitudes and longitudes of the principal places on the globe, and their various bearings and relations have been determined, so that we can now take a view of the world we inhabit in all its multifarious aspects, and direct our course to any quarter of it, either for business, for pleasure, or for the promotion of philanthropic objects. Thus, Astronomy has likewise become of immense utility to *Trade* and *Commerce*, in opening up new emporiums for our manufacture, in augmenting and multiplying the sources of wealth, in promoting an intercourse between the most distant nations, and enabling us to procure, for our accommodation or luxury, the productions of every climate. If Science has now explored almost every region; if Politics and Philosophy have opened a communication between the remotest inhabitants of the globe; if alliances have been formed between the most distant tribes of mankind; if Traffic has explored the multifarious productions of the earth and seas, and transported them from one country to another, and, if heathen lands and barbarous tribes have been "visited with the Day-spring from on high, and the knowledge of salvation,"—it is owing to the aids derived from the science of the stars, without which the continents, the islands, and the different aspects of our globe would never have been explored by those who were separated from them by intervening oceans.

This science has been no less useful to

AGRICULTURE

and to the cultivators of the earth. The successful cultivation of the soil depends on a knowledge of the course of the sun, the exact length of the seasons, and the periods of the year most proper for the operations of tillage and sowing. The ancients were directed in these operations, in the first instance, by observing the courses of the moon, and that twelve revolutions of this luminary corresponded nearly with one apparent revolution of the sun. But finding the coincidence not exact, and that the time of the seasons was changing—in order to know the precise bounds of the sun's annual course, and the number of days corresponding to his apparent yearly revolution, they were obliged to examine with care what stars were successively obscured in the evening by the sun, or overpowered by the splendor of his light, and what stars were beginning to emerge from his rays, and to re-appear before the dawn of the morning. By certain ingenious methods, and numerous and attentive observations, they traced out the principal stars that lay in the line of the sun's apparent course, gave them certain names by which they might be afterwards distinguished, and then divided the circle of the heavens in which the sun appears to move, first into quadrants, and afterwards into 12 equal parts, now called the *signs of the Zodiac*, which they distinguished by names corresponding to certain objects and operations connected with the different seasons of the year. Such were the means requisite to be used for ascertaining the length of the year, and the commencement of the different seasons, and for directing the labors of the husbandman; and, were the knowledge of these things to be obliterated by any extensive moral or physical convulsion, mankind would again be under the necessity of having recourse to astronomical observations for determining the limits of the solar year, and the course of the seasons. Although we find no difficulty, in the present day, and require no anxious observations, in determining the seasons, yet, before astronomical observations were made with some degree of accuracy, the ancient Greeks had to watch the rising of *Arcturus*, the *Pleiades* and *Orion*, to mark their seasons, and to determine the proper time for their agricultural labors. The rising of the star *Sirius* along with the sun, announced to the Egyptians the period when they might expect the overflowing of the Nile, and, consequently, the time when they were to sow their grain, cut their canals and reservoirs, and prepare the way for their expected harvest.

The science of

CHRONOLOGY

likewise depends on celestial observations. The knowledge of an exact measure of time is of considerable importance in arranging and conducting the affairs of life, without which, society in its movements would soon run into confusion. For example, if we could not ascertain, within an hour or two, when an assembly or any concourse of human beings was to meet for an important purpose, all such purposes would soon be frustrated, and human improvement prevented. Our ideas of *time* or *succession* in duration, are derived from *motion;* and in order to its being divided into equal parts, the motions on which we fix as standards of time must be *constant* and *uniform*, or at least, that any slight deviation from uniformity shall be capable of being ascertained. But we have no uniform motion on earth by which the lapse of duration can be accurately measured. Neither the flight of birds, the motion of the clouds, the gentle breeze, the impetuous whirlwind, the smooth-flowing river, the roaring cataract, the falling rain, nor even the flux and reflux of the ocean, regular as they generally are, could afford any certain standard for the measure of time. It is, therefore, to the motion of the celestial orbs alone that we can look for a standard of duration that is certain and invariable, and not liable to the changes that take place in all terrestrial movements. Those magnificent globes which roll around us in the canopy of the sky—whether their motions be considered as real or only apparent, move with an order and regularity which is not found in any physical agents connected with our globe; and when from this quarter we have derived any one invariable measure of time, we can subdivide it into the minutest portions, to subserve all the purposes of civil life, and the improvements of science. Without the aids of astronomy, therefore, we should have had no accurate ideas of the lapse of time, and should have been obliged, like the rude savage of the desert, to compute our time by the falls of snow, the succession of rainy seasons, the melting of the ice, or the progress and decay of vegetation.

Celestial observations, in consequence of having ascertained a regular measure of time, have enabled us to fix *chronological dates*, and to determine the principal epochs of History. Many of those epochs were coincident with remarkable eclipses of the sun or moon, which the ancients regarded as prognostics of the loss of battles, the death of monarchs, and the fall of empires; and which are recorded in connection with such events, where no dates are mentioned. The astronomer, therefore, knowing the invariable movements of the heavenly orbs, and calculating backwards through the past periods of time, can ascertain what remarkable eclipses must have been visible at any particular time and place and consequently, can determine the precise date of contemporary events. Calvisius, for example, founds his Chronology on 144 eclipses of the sun, and 127 of the moon, which he had calculated for the purpose of determining epochas and settling dates. The grand conjunction of the planets Jupiter and Saturn, which occurs once in 800 years, in the same point of the zodiac, and which has happened only eight times since the Mosaic Creation, furnishes Chronology with incontestable proofs of the date of events, when such phenomena happen to be recorded. On such data, Sir Isaac Newton determined the period when Thales the philosopher flourished, particularly from the famous eclipse which he predicted, and which happened just as the two armies under *Alyattes*, king of Lydia, and Cyaxares the Mede were engaged; and which has been calculated to have happened in the 4th year of the 43d Olympiad, or in the year before Christ 603. On similar grounds Dr. Halley, a celebrated astronomer of the last century, determined the very day and hour of the landing of Julius Cesar in Britain, merely from the circumstances stated in the "Commentaries" of that illustrious general.

Astronomy has likewise lent its aid to the

PROPAGATION OF RELIGION,

and the conversion of the heathen world. For without the light derived from this celestial science, oceans would never have been traversed, nor the continents and islands explored where benighted nations reside, and, consequently, no messengers of Peace could have been dispatched to teach them "the knowledge of salvation, and to guide their steps in the way of peace." But, with the direction afforded by the heavenly orbs and the magnetic needle, thousands of Christian missionaries, along with millions of bibles, may now be transported to the most distant continents and islands of the ocean, to establish among them the 'Law and Testimony" of the Most High—to illume the darkness and counteract the moral abominations and idolatries of the Pagan world. If the predictions of ancient prophets are to be fulfilled; if the glory of Jehovah is to cover the earth; if "the isles afar off," that have not yet heard of the fame of the Redeemer, nor seen his glory, are to be visited with the "Day-spring from on high," and enrolled among the citizens of Zion; if the world is to be regenerated, and Righteousness and Praise to spring forth before all nations—those grand events will be accomplished partly through the influence and direction of those celestial luminaries which are placed in the firmament to be for signs, and for seasons, and for days and years. The light reflected from the material heavens will lend its aid in illuminating the minds of the benighted tribes of mankind, till they be prepared for being transported into those celestial mansions where knowledge shall be perfected, and sovereign power triumphant. It will be likewise from aid derived from the heavenly orbs that the desolate wastes of the globe in every region will be cultivated and replenished with inhabitants. For the Almighty "created not the earth in vain, but formed it to be inhabited;" and his purpose in this respect must ultimately be accomplished; and the process of peopling and cultivation is now going forward in New Holland, Van Diemen's Land, Africa, the Western States of America, and other regions where sterility and desolation have prevailed since the universal Deluge. But how could colonies of men be transported from civilized nations to those distant regions, unless by the guidance of celestial luminaries, and by the aid of those arts which are founded on the observations of astronomy? So that this science exerts an extensive and beneficial influence over the most important affairs of mankind.

In short, astronomy, by unfolding to us the causes of certain celestial phenomena, has tended to

DISSIPATE SUPERSTITIOUS NOTIONS

and vain alarms. In former ages the approach of a blazing comet, or a total eclipse of the sun or moon, were regarded with universal consternation as prognostics of impending calamities, and as harbingers of Divine vengeance. And even in the present day, such notions prevail among most of those nations and tribes that are unacquainted with astronomical science. During the darkness occasioned by a solar eclipse, the lower orders of Turkey have been seen assembling in clusters in the streets, gazing wildly at the sun, running about in wild distraction, and firing volleys of muskets at the sun to frighten away the monster by which they supposed it was about to be devoured. The Moorish song of death, or the howl they make for the dead, has been heard, on such occasions, resounding from the mountains and the vales, while the women brought into the streets all the brass pans, and vessels, and iron utensils they could collect, and striking them with all their force, and uttering dreadful screams, occasioned a horrid noise that was heard for miles around. But astronomy has put to flight such terrific phantoms and groundless alarms, by unfolding to us the true causes of all such phenomena, and showing us that they happen in exact conformity with those invariable laws by which the Almighty conducts the machine of the universe—that eclipses are merely the effects of the shadow of one opaque globe falling upon another, and that comets are bodies which move in regular, but long elliptical orbits—which appear and disappear in stated periods of time, and are destined to subserve some grand and beneficent designs in the system to which they belong. So that we may now contemplate all such celestial phenomena, not only with composure and tranquillity, but with exultation and delight. In short, astronomy has undermined the absurd and fallacious notions by which the professors of *Judicial Astrology* have attempted to impose on the credulity of mankind, under pretence of disclosing the designs of *Fate*, and the events of futurity. It shows us, that the stars are placed at immeasurable distances from our terrestrial sphere—that they can have no influence upon the earth, but what arises from the law of universal gravitation—that the great end for which they were created was to diffuse light, and to perform other important services in regions infinitely distinct from the sphere we occupy—that the planets are bodies of different sizes, and somewhat similar to the globe on which we live—that all their aspects and conjunctions are the result of physical laws which are regular and immutable—and that no *data* can be ascertained on which it can be proved that they exert a *moral* influence on the temperaments and destinies of men, except in so far as they tend to raise our affections to their Almighty Author, and excite us to confide in his care, and to contemplate the effects of his wisdom and omnipotence. The heavens are set before us, not as the "Book of Fate," in which we may pry into the secrets of our future destiny, which would only serve to destroy activity, and increase the pressure of our present afflictions—but as the "Book of God," in which we may read his wondrous works, contemplate the glory of his eternal empire, and be excited to extend our views to those expansive scenes of endless felicity which await the faithful in the realms above.

Independently of the considerations above stated, the study of astronomy is attended with many advantages in a moral, intellectual, and religious point of view.

1. This department of science unfolds to us *the most striking displays of the perfections of the Deity*—particularly the grandeur of his *Omnipotence.* His *Wisdom* is conspicuously displayed in the general arrangement of the heavenly orbs, particularly in reference to the globes which compose the solar system—in placing near the center of this system that immense luminary the *Sun*, from whence light and heat might be distributed, in due proportion, to all the worlds that roll around it—in nicely proportioning the motions and distances of all the planets, primary and secondary—in uniting them in one harmonious system, by one grand universal law which prevents them from flying off in wild confusion through the infinity of space—in the constancy and regularity of their motions, no one interfering with another, or deviating from the course prescribed—in the exactness with which they run their destined rounds, finishing their circuits with so much accuracy as not to deviate from their periods of revolution the hundredth part of a minute in a thousand years—in the spherical figures given to all those mighty orbs, and the diurnal motions impressed upon them, by which a due proportion of light and heat is diffused over every part of their surface. The *Benevolence* of the Deity shines no less conspicuous in those upper regions, in ordering all the movements and arrangements of the celestial globes so as to act in subserviency to the comfort and happiness of sentient and intelligent beings. For, the wisdom of God is never employed in devising means without an end; and the grand end of all his arrangements, in so far as our views extend, is the communication of happiness; and it would be inconsistent with the wisdom and other perfections of God not to admit, that the same end is kept in view *in every part of his dominions*, however far removed from the sphere of our contemplation. The heavens, therefore, must be considered as presenting a boundless scene of Divine benevolence. For they unfold to view a countless number of magnificent globes, calculated to be the habitations of various orders of beings, and which are, doubtless, destined to be the abodes of intellectual life. For the character of the Deity would be impeached, and his wisdom virtually denied, were we to sup-

pose him to arrange and establish a magnificent series of *means* without an *end* corresponding, in utility and dignity, to the grandeur of the contrivance. When, therefore, we consider the innumerable worlds which must exist throughout the immensity of space, the countless myriads of intelligences that people them, the various ranks and orders of intellect that may exist among them, the innumerable diversified arrangements which are made for promoting their enjoyment, and the peculiar displays of Divine benignity enjoyed in every world—we are presented with a scene of Divine goodness and beneficence which overpowers our conceptions, and throws completely into the shade all that we perceive or enjoy within the confines of this sublunary world. And, although the minute displays of Divine benevolence in distant worlds are not yet particularly unfolded to our view, yet this circumstance does not prove that no such displays exist;—and as we are destined to an immortal life in another region of creation, we shall, doubtless, be favored with a more expansive view of the effects of Divine benignity in that eternal scene which lies before us.

But this science exhibits a more striking display than any other of the *Omnipotent energies* of the Eternal Mind. It presents before us objects of overpowering magnitude and splendor—planetary globes a thousand times larger than the earth—magnificent rings which would nearly reach from the earth to the moon, and would inclose within their vast circumference 500 worlds as large as ours—suns a million times larger than this earthly ball, diffusing their light over distant worlds—and these suns scattered in every direction through the immensity of space, at immeasurable distances from each other, and in multitudes of groups which no man can number; presenting to the eye and the imagination a perspective of starry systems, boundless as immensity. It presents to our view motions so astonishing as to overpower and almost terrify the imagination—bodies a thousand times larger than the earth flying with a velocity of 29,000 miles an hour, performing circuits more than three thousand millions of miles in circumference, and carrying along with them a retinue of revolving worlds in their swift career; nay, motions, at the rate of 880,000 miles an hour, have been perceived among the celestial orbs, which as far surpass the motions we behold around us in this lower world, as the heavens in height surpass the earth. Such motions are perceived not only in the solar system, but in the most distant regions of the universe, among *double stars*—they are regular and uninterrupted—they have been going forward for thousands, perhaps for millions of years—there is perhaps no body in the universe but is running its round with similar velocity; and it is not unlikely that the whole machine of universal nature is in perpetual motion amidst the spaces of immensity, and will continue thus to move throughout all the periods of endless duration. Such objects and such motions evidently display the omnipotence of the Creator beyond every other scene which creation presents; and, when seriously contemplated, cannot but inspire us with the most lofty and impressive conceptions of the "eternal power" and majesty of Him who sits on the throne of the universe, and by whom all its mighty movements are conducted. They demonstrate, that his agency is universal and *uncontrollable*—that he is able to accomplish all his designs, however incomprehensible to mortals—that no created being can frustrate his purposes, and that he is worthy of our highest affection, and our incessant adoration.

2. Astronomy displays before us *the extent and grandeur of God's universal empire.* The globe we inhabit, with all its appendages, forms a portion of the Divine empire, and, when minutely investigated, exhibits a striking display of its Creator's power, benignity, and intelligence. But it forms only one small province of his universal dominions—an almost undistinguishable speck in the great map of the universe: and if we confine our views solely to the limits of this terrestrial ball, and the events which have taken place on its surface, we must form a very mean and circumscribed idea of the extent of the Creator's kingdom and the range of his moral government. But the discoveries of astronomy have extended our views to other provinces of the empire of Omnipotence, far more spacious and magnificent. They demonstrate, that this earth, with all its vast oceans and mighty continents, and numerous population, ranks among the smaller provinces of this empire—that the globes composing the system to which it belongs, (without including the sun,) contain an extent of territory more than two thousand times larger than our world—that the sun himself is more than 500 times larger than the whole, and that, although they were all at this moment buried in oblivion, they would scarcely be missed by an eye that could survey the whole range of creation. They demonstrate, that ten thousands of suns, and ten thousand times ten thousands of revolving worlds, are dispersed throughout every region of boundless space, displaying the creating and supporting energies of Omnipotence; and consequently, are all under the care and superintendence of Him "who doeth according to his will in the armies of heaven, and among the inhabitants of the earth." Such an empire, and such only, appears corresponding to the perfections of Him who has existed from eternity past, whose power is irresistible, whose goodness is unbounded, and whose presence fills the immensity of space; and it leads us to entertain the most exalted sentiments of admiration at the *infinite intelligence* implied in the *superintendence* of such vast dominions, and at the boundless *beneficence* displayed among the countless myriads of sensitive and intellectual beings which must people his wide domains.

3. The objects which this science discloses, *afford subjects of sublime contemplation*, and tend to *elevate the soul above vicious passions and groveling pursuits.* In the hours of retirement and solitude what can be more delightful, than to wing our way in imagination amidst the splendid objects which the firmament displays—to take our flight along with the planets in their wide career—to behold them running their ample rounds with velocities forty times swifter than a cannon ball—to survey the assemblages of their moons, revolving around them in their respectives orders, and carried at the same time, along with their primaries, through the depths of space—to contemplate the magnificent arches which adorn the firmament of Saturn, whirling round that planet at the

rate of a thousand miles in a minute, and displaying their radiance and majestic movements to an admiring population—to add scene to scene, and magnitude to magnitude, till the mind acquire an ample conception of such august objects—to dive into the depths of infinite space till we be surrounded with myriads of suns and systems of worlds, extending beyond the range of mortal comprehension, and all running their appointed rounds, and accomplishing the designs of beneficence in obedience to the mandate of their Almighty Author? Such objects afford matter for rational conversation, and for the most elevated contemplation. In this ample field the most luxuriant imagination may range at large, representing scenes and objects in endless variety and extent; and, after its boldest excursions, it can scarcely go beyond the reality of the magnificent objects which exist within the range of creating power and intelligence.

The frequent contemplation of such objects tends to enlarge the capacity of the mind, to ennoble the human faculties, and raise the soul above groveling affections and vicious pursuits. For the dispositions of mankind and their active pursuits generally correspond to the train of thought in which they most frequently indulge. If these thoughts run among puerile and vicious objects, such will be the general character of their affections and conduct. If their train of thinking take a more elevated range, the train of their actions, and the passions they display, will, in some measure, be correspondent.

Can we suppose, that a man whose mind is daily conversant with the noble and expansive objects to which I have adverted, would have his soul absorbed in the pursuits of ambition, tyranny, oppression, war, and devastation?

Would he rush like a madman through burning cities, and mangled carcasses of the slain, in order to trample underfoot the rights of mankind, and enjoy a proud pre-eminence over his fellows—and find pleasure in such accursed pursuits?

Would he fawn on statesmen and princes, and violate every moral principle, in order to obtain a pension, or a post of opulence or honor? Would he drag his fellow-men to the stake, because they worshiped God according to the dictates of their consciences, and behold with pleasure their bodies roasting in the flames?

Would he drive men, women, and children from their homes, loaded with chains and fetters, to pine in misery and to perish in a distant land, merely because they asserted the rights to which they were entitled as citizens and as rational beings?

Or, would he degrade himself below the level of the brutes by a daily indulgence in *rioting* and *drunkenness*, till his faculties were benumbed, and his body found wallowing in the mire?

It is scarcely possible to suppose that such passions and conduct would be displayed by the man who is habitually engaged in celestial contemplations, and whose mind is familiar with the august objects which the firmament displays. "If men were taught to act in view of all the bright worlds which are looking down upon them, they could not be guilty of those abominable cruelties" which some scenes so mournfully display. We should then expect, that the iron rod of oppression would be broken in pieces—that war would cease its horrors and devastations—that liberty would be proclaimed to the captives—that "righteousness would run down our streets as a river," and a spirit congenial to that of the inhabitants of heaven would be displayed by the rulers of nations, and by all the families of the earth. For all the scenes which the firmament exhibits have a tendency to inspire *tranquillity*—to produce a love of *harmony* and *order*, to *stain the pride of human grandeur*—to display the riches of *Divine beneficence*—to excite *admiration* and *reverence*—and *to raise the soul to God* as the Supreme Director of universal nature, and the source and center of all true enjoyment;—and such sentiments and affections are directly opposed to the degrading pursuits and passions which have contaminated the society of our world, and entailed misery on our species.

I might have added, on this head, that the study of this subject has a peculiar tendency to sharpen and *invigorate* the mental faculties. It requires a considerable share of attention and of intellectual acumen to enter into all the particulars connected with the principles and facts of astronomical science. The elliptical form of the planetary orbits, and the anomalies thence arising, the mutation of the earth's axis, the causes of the seasons, the difficulty of reconciling the apparent motions of the planets with their real motions in circular or elliptical orbits, the effects produced by centrifugal and centripetal forces, the precession of the equinoxes, the aberration of light, the method of determining the distances and magnitudes of the celestial bodies, mean and apparent time, the irregularity of the moon's motion, the difficulty of forming adequate ideas of the immense spaces in which the heavenly bodies move, and their enormous size, and various other particulars, are apt, at first view, to startle and embarrass the mind, as if they were beyond the reach of its comprehension. But, when this science is imparted to the young under the guidance of enlightened instructors—when they are shown not merely pictures, globes and orreries, but directed to observe with their own eyes, and with the assistance of telescopes, all the interesting phenomena of the heavens, and the motions which appear, whether real or apparent—when they are shown the spots of the sun, the moons and belts of Jupiter, the phases of Venus, the rings of Saturn, and the mountains and vales which diversify the surface of the moon—such objects tend to awaken the attention, to expand the faculties, to produce a taste for rational investigation, and to excite them to more eager and diligent inquiries into the subject. The objects appear so grand and novel, and strike the senses with so much force and pleasure, that the mind is irresistibly led to exert all its energies in those investigations and observations by which it may be enabled to grasp all the principles and facts of the science. And every difficulty which is surmounted adds a new stimulus to the exertions of the intellect, urges it forward with delight in the path of improvement, and thus invigorates the mental powers, and prepares them for engaging with spirit and alacrity in every other investigation.

4. The study of astronomy has a tendency *to moderate the pride of man*, and to promote *humility*. Pride is one of the distinguishing

characteristics of puny man, and has been one of the chief causes of all the contentions, wars, devastations, oppressions, systems of slavery, despotisms, and ambitious projects which have desolated and demoralized our sinful world. Yet there is no disposition more incongruous to the character and circumstances of man. Perhaps there are no rational beings throughout the universe among whom pride would appear more unseemly or incompatible than in man; considering the abject situation in which he is placed. He is exposed to innumerable degradations and calamities, to the rage of storms and tempests, the devastations of earthquakes and volcanoes, the fury of whirlwinds, and the tempestuous billows of the ocean, the ravages of the sword, pestilence, famine, and numerous diseases, and, at length, he must sink into the grave, and his body become the companion of worms. The most dignified and haughty of the sons of men are liable to such degradations, and are frequently dependent on the meanest fellow-creatures whom they despise, for the greater part of their accommodations and comforts. Yet, in such circumstances, man, that puny worm of the dust, whose knowledge is so limited, whose follies are so numerous and *glaring*—has the effrontery to strut in all the haughtiness of *pride*, and to glory in his shame. When scriptural arguments and motives produce little effect, I know no considerations which have a more powerful tendency to counteract this deplorable propensity of human beings than those which are borrowed from the objects connected with astronomy. They show us what an insignificant being—what a mere atom, indeed, man appears amidst the immensity of creation. What is the whole of this globe, compared with the solar system, which contains a mass of matter ten hundred thousand times greater? What is it in comparison of the hundred millions of suns and worlds which the telescope has descried throughout the starry regions, or of that infinity of worlds which doubtless lie beyond the range of human vision in the unexplored regions of immensity? What, then, is a kingdom, or a province, or a baronial territory, of which we are as proud as if we were the lords of the universe, and for which we engage in so much devastation and carnage? What are they when set in competition with the glories of the sky? Could we take our station on the lofty pinnacles of heaven, and look down on this scarcely distinguishable speck of earth, we should be ready to exclaim with *Seneca*, "Is it to this little spot that the great designs and vast desires of men are confined? Is it for this there is so much disturbance of nations, so much carnage, and so many ruinous wars? O folly of deceived men, to imagine great kingdoms in the compass of an atom, to raise armies to divide a *point* of earth with the sword!" It is unworthy of the dignity of an immortal mind to have its affections absorbed in the vanishing splendors of earthly grandeur, and to feel proud of the paltry possessions and distinctions of this sublunary scene. To foster a spirit of pride and vain-glory in the presence of Him who "sitteth on the circle of the heavens," and in the view of the overwhelming grandeur and immensity of his works, is a species of presumption and arrogance of which every rational mind ought to feel ashamed. And, therefore, we have reason to believe, that those multitudes of fools, "dressed in a little brief authority," who walk in all the loftiness of pride, have not yet considered the rank they hold in the scale of universal being; and that a serious contemplation of the immensity of creation would have a tendency to convince us of our ignorance and nothingness, and to humble us in the dust, in the presence of the Former and Preserver of all worlds. We have reason to believe that the most exalted beings in the universe—those who are furnished with the most capacious powers, and who have arrived at the greatest perfection in knowledge—are distinguished by a proportional share of humility; for, in proportion as they advance in their surveys of the universal kingdom of Jehovah, the more will they feel their comparative ignorance, and be convinced of their limited faculties, and of the infinity of objects and operations which lie beyond their ken. At the same time they will feel, that all the faculties they possess were derived from Him who is the original fountain of existence, and are continually dependent for their exercise on his sustaining energy. Hence we find, that the angelic tribes are eminently distinguished for the exercise of this heavenly virtue. They "cover their faces with their wings" in the presence of their Sovereign, and fly, with cheerfulness, at his command, to our degraded world, "to minister to the heirs of salvation." It is only in those worlds where *ignorance* and *depravity* prevail (if there be any such besides our own) that such a principle as *pride* is known or cherished in the breast of a dependent creature—and therefore every one in whom it *predominates*, however high his station or worldly accomplishments, or however abject his condition may be, must be considered as either ignorant or depraved, or more properly, as having both those evils existing in his constitution, the one being the natural and necessary result of the other.

5. The studies connected with astronomy tend to prepare the soul for *the employments of the future world.* In that world, the glory of the Divine perfections, as manifested throughout the illimitable tracts of creation, is one of the objects which unceasingly employ the contemplation of the blessed. For they are represented in their adorations as celebrating the attributes of the Deity displayed in his operations: "Great and marvelous are thy works, Lord God Almighty! thou art worthy to receive glory and honor and power, for thou hast created all things, and for thy pleasure they are and were created." Before we can enter that world and mingle with its inhabitants, we must acquire a *relish* for their employments, and some acquaintance with the objects which form the subject of their sublime investigations; otherwise we could feel no enjoyment in the society of heavenly intelligences, and the exercises in which they engage. The investigations connected with astronomy, and the frequent contemplation of its objects, have a tendency to prepare us for such celestial employments, as they awaken *attention* to such subjects, as they invigorate the faculties, and enlarge the capacity of the intellect, as they suggest sublime inquiries, and desires for further information which may afterwards be gratified; as they form the groundwork of the progress we may afterwards make in that state in our surveys of the Divine operations, and as they habituate the mind to

take large and comprehensive views of the empire and moral government of the Almighty. Those who have made progress in such studies, under the influence of holy dispositions may be considered as fitted to enter heaven with peculiar advantages, as they will then be introduced to employments and investigations to which they were formerly accustomed, and for which they were prepared—in consequence of which they may be prepared for filling stations of superior eminence in that world, and for directing the views and investigations of their brethren who enjoyed few opportunities of instruction and improvement in the present state. For we are informed, in the sacred records, that "they who are wise," or as the words should be rendered, "they who excel in wisdom shall shine as the brightness of the firmament, and they that turn many to righteousness, as the stars for ever and ever."

6. The researches of astronomy demonstrate, that *it is in the power of the Creator to open* to his intelligent offspring *endless sources of felicity*. In looking forward to the scene of our future destination, we behold a series of ages rising in succession without any prospect of a termination; and, at first view, it might admit of a doubt, whether the universe presents a scene so diversified and boundless, that intelligent beings, during an endless duration, could expect that new scenes of glory and felicity might be continually opening to their view, or, whether the same series of perceptions and enjoyments might not be reiterated so as to produce satiety and indifference. Without attempting positively to decide on the particular scenes or sources of happiness that may be opened in the eternal world, it may be admitted, that *the Deity has it in his power* to gratify his rational creatures, during every period of duration, with new objects and new sources of enjoyment; and, that it is the science of astronomy alone which has presented us with a demonstration, and a full illustration of this important truth. For, it has displayed before us a universe boundless in its extent, diversified as to its objects, and infinite as to their number and variety. Even within the limits of human vision the number of worlds which exist cannot be reckoned less than *three thousand millions;* and those which are nearest to us, and subject to our particular examination, present varieties of different kinds, both as to magnitude, motion, splendor, color and diversity of surface—evidently indicating, that every world has its *peculiar scenes* of beauty and grandeur. But, as no one will be so presumptuous as to assert, that the boundaries of the universe terminate at the limits of human vision, there may be an assemblage of creation beyond all that is visible to us, which as far exceeds the visible system as the vast ocean exceeds in magnitude a single drop of water; and this view is nothing more than compatible with the idea of a Being whose creating energies are infinite, and whose presence fills immensity. Here, then, we have presented to our contemplation a boundless scene, corresponding, in variety and extent of space, to the ages of an endless duration; so that we can conceive an immortal mind expatiating amidst objects of benignity, sublimity and grandeur, ever varied and ever new, throughout an eternal round of existence, without ever arriving at a point, where it might be said, "Hitherto shalt thou come, but no "

ther." And we have reason to conclude that such will be the privilege and enjoyment of all holy beings. For we are informed on the authority of inspiration, that "*in God's presence there is fulness of joy, and at his right hand are pleasures for evermore.*

7. The science of astronomy is a study which will be prosecuted without intermission in the eternal world. This may be inferred from what has been already stated. For it is chiefly among the numerous worlds dispersed throughout the universe that God is seen, his perfections manifested, and the plans of his moral government displayed before the eyes of unnumbered intelligences. The heavens constitute by far the grandest and most extensive portion of the empire of Omnipotence; and if it shall be one part of the happiness of immortal spirits to behold and investigate the beauty, grandeur and beneficence displayed throughout this empire, we may rest assured, that they will be *perpetually* employed in such exercises; since the objects of their investigation are boundless as immensity;—or, in other words, astronomy, among other branches of celestial science, will be their unceasing study and pursuit. As it has for its object, to investigate the motions, relations, phenomena, scenery, and the ultimate destination of the great bodies of the universe, the subject can never be exhausted. Whatever may be said in regard to the absolute perfection of other sciences, astronomy can never be said, at any future period of duration, to have arrived at perfection, in so far as it is a subject of study to *finite* minds; and, at this moment, even in the view of the Infinite Mind that created the universe, its objects may not yet be completed. For we have reason to believe that the work of creation is still going forward, and, consequently, that new worlds and systems may be continually emerging from nothing under the energies of Creating Power. However capacious, therefore, the intellects of good men, in a future world, may be, they will never be able fully to explore the extent and variety, "the riches and glory" of Him "who dwells in light unapproachable;"—yea, the most exalted of created intelligences, wherever existing, although their mental powers and activities were incomparably superior to those of man, will be inadequate to a full investigation and comprehension of the grandeur and sublimities of that kingdom which extends throughout the regions of immensity. And this circumstance will constitute one ingredient of their happiness, and a security for its permanency. For, at every period of infinite duration, they will be enabled to look forward to a succession of scenes, objects and enjoyments different from all they had previously contemplated or experienced, without any prospect of a termination. We may therefore conclude, that, unless the material universe be demolished, and the activities of immortal minds suspended, the objects of astronomy will continue throughout eternity to be the subject of study, and of unceasing contemplation.

Such are some of the advantages attending the study of the science of astronomy. It lies at the foundation of our geographical knowledge—it serves as a handmaid and director to the traveler and navigator—it is subservient to the purposes of universal commerce—it determines the seasons, and directs the operations of the husbandman—it supplies us with an equable standard of time, and settles the events of history—it lends its aid to the propagation of religion, and undermines the foundation of superstition and astrology. Above all, it illustrates the glory of the perfections of the Deity—displays the extent and grandeur of his universal empire—affords subjects of sublime contemplation—enlarges the conceptions, and invigorates the mental powers—counteracts the influence of pride, and promotes the exercise of humility—prepares the soul for the employments of the future world—and demonstrates, that the Creator has it in his power to open up endlessly diversified sources of happiness to every order of his intelligent offspring, throughout all the revolutions of eternity. The moral advantages arising from the study of this science, however, cannot be appreciated or enjoyed, unless such studies and investigations be prosecuted in connection with the facts and principles of Revelation. But, when associated with the study of the Scriptures, and the character of God therein delineated, and the practice of Christian precepts, they are calculated "to make the man of God perfect," to enlarge his conceptions of Divine perfection, and to expand his views of "the inheritance of the saints in light."

Such being the advantages to be derived from the study of this science, it ought to form a subject of attention in every seminary intended for the mental and moral improvement of mankind. In order to the improvement of the young in this science, and that its objects may make a deep impression on their minds, they should be directed to make frequent observations, as opportunity offers, on the movements of the nocturnal heavens, and to ascertain all the facts which are obvious to the eye of an attentive spectator. And, while they mark the different constellations, the apparent diurnal motion of the celestial vault, the planets in their several courses, and the moon walking in her brightness among the host of stars—they should be indulged with views of the rings of Saturn, the belts and satellites of Jupiter, the phases of Mercury and Venus, the numerous groups of stars in the *Milky Way*, the double and treble stars, the most remarkable *Nebulæ*, the mountains and plains, the caverns and circular ridges of hills which diversify the surface of the moon, as they appear though good achromatic or reflecting telescopes. Without actual observation, and the exhibition of such interesting objects, the science of astronomy makes, comparatively, little impression on the mind. Our school books on astronomy should be popular in their language and illustrations, but, at the same time, they should be *comprehensive* in their details, and every exhibition should be clear and *well defined*. They should contain, not merely descriptions of facts, to be received on the authority of the author or the instructor, but illustrations of the *reasons* or arguments on which the conclusions of astronomy are founded, and of the *modes* by which they have been ascertained. And, while planetariums, celestial globes, and planispheres of the heavens are exhibited, care should be taken to direct the observations of the pupils as frequently as possible to the objects themselves, and to guard them against the *limited* and *distorted* notions which all kinds of artificial representations have a tendency to convey.

There is still room for improvement in all the initatory books on this subject, I have examined; but such books are now rapidly improving, both as to their general plan, and the interesting nature of their details. I have seen nothing superior in this respect, or better adapted to the purpose of rational instruction, than Mr. Burritt's excellent work entitled, "The Geography of the Heavens," second edition, comprising 342 closely printed pages. It contains, in the first place, a full and interesting description of all the constellations, and principal stars in the heavens, interspersed with a great variety of mythological, historical and philosophical information, calculated to amuse and instruct the general reader, and to arrest the attention of the young. The descriptions of the bodies connected with the solar system are both popular and scientific, containing a lucid exhibition of the facts which have been ascertained respecting them, and a rational explanation of the phenomena connected with their various aspects and motions. The *Celestial Atlas* which accompanies the work is varied, comprehensive, and judiciously constructed, and forms the most complete set of planispheres, for the purpose of teaching, which has hitherto been published. It consists of four maps about fourteen inches square, delineated on the same principles as geographical projections, exhibiting the stars that pass near the meridian at a certain hour, along with the circumjacent constellations for every month, and for every day of the year. Besides these there are two circumpolar maps of the northern and southern hemispheres of the heavens, and a planisphere on the principle of Mercator's projection, which exhibits at one view the sphere of the heavens, and the relative positions of the different constellations and principal stars. With the assistance of these maps, which in a great measure supersede the use of a celestial globe, an intelligent teacher may, at certain intervals in the course of a year, render his pupils familiar with most of the visible stars in the heavens: and they will make a deeper impression on their minds when taught in this way, than by the use of a globe. This work, on the whole, indicates great industry and research on the part of the author, and a familiar acquaintance with the various departments of the science of the heavens. He has derived his materials from the most valuable and modern works of science, and has introduced not a few illustrations and calculations of his own, which tend to enhance the general utility of the work. The moral and religious reflections which the objects of this science natu ally suggest, have not been overlooked, and, I trust, will have a tendency to raise the minds of the young to that Almighty Being, whose power, wisdom, and superintending providence are so strikingly displayed throughou the regions of the firmament.

PRELIMINARY CHAPTER.

In entering upon this study, the phenomena of the heavens, as they appear in a clear evening, are the first objects that demand our attention. Our first step is to learn the names and positions of the heavenly bodies, so that we can identify, and distinguish them from each other.

In this manner, they were observed and studied ages before books were written, and it was only after many, careful and repeated observations, that systems and theories of Astronomy were formed. To the visible heavens, then, the attention of the pupil should be first directed, for it is only when he shall have become, in some measure, familiar with them, that he will be able to *locate* his Astronomical knowledge, or fully comprehend the terms of the science.

For the sake of convenient reference, the heavens were early divided into constellations, and particular names assigned to the constellations and to the stars which they contain. A constellation may be defined to be a cluster or group of stars embraced in the outline of some figure. These figures are, in many cases, creations of the imagination; but in others, the stars are in reality so arranged as to form figures which have some resemblance to the objects whose names have been assigned to them.

These divisions of the celestial sphere bear a striking analogy to the civil divisions of the globe. The constellations answer to states and kingdoms, the most brilliant clusters to towns and cities, and the number of stars in each, to their respective population. The pupil can trace the boundaries of any constellation, and name all its stars, one by one, as readily as he can trace the boundaries of a state, or name the towns and cities from a map of New England. In this sense, there may be truly said to be a Geography of the Heavens.

The stars are considered as forming, with reference to their magnitudes, six classes; the brightest being called stars of the first magnitude, the next brightest, stars of the second magnitude, and so on to the sixth class, which consists of the smallest stars visible to the naked eye. In order to be able

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Why, in entering upon the study of Astronomy, should the attention of the pupil be first directed to the visible heavens? Why were the heavens early divided into constellations, and names assigned to the constellations and the stars? What is a constellation? Do these figures really exist in the skies? *In what sense may there truly be said to be a Geography of the Heavens?* How many classes are the stars considered as forming with reference to their magnitude?

to designate, with precision their situations, imaginary circles have been considered as drawn in the heavens, most of which correspond to and are in the same plane with similar circles, supposed, for similar purposes, to be drawn on the surface of the Earth.

In order to facilitate the study of it, artificial representations of the heavens, similar to those of the surface of the Earth, have been made. Thus, a Celestial Atlas composed of several maps, accompanies this work. Before, however, proceeding to explain its use, it is necessary to make the pupil acquainted with the imaginary circles alluded to above.

Circles of the Sphere.—The *Axis of the Earth* is an imaginary line, passing through its center, north and south, about which its diurnal revolution is performed.

The *Poles of the Earth* are the extremities of its axis.

The *Axis of the Heavens* is the axis of the Earth produced both ways to the concave surface of the heavens.

The *Poles of the Heavens* are the extremities of their axis.

The *Equator of the Earth* is an imaginary great circle passing round the Earth, east and west, every where equally distant from the poles, and dividing it into northern and southern hemispheres.

The *Equator of the Heavens*, or *Equinoctial*, is the great circle formed on the concave surface of the heavens, by producing the plane of the Earth's equator.

A plane is that which has surface but not thickness. The plane of a circle is that imaginary superficies which is bounded by the circle.

The *Rational Horizon* is an imaginary great circle, whose plane, passing through the center of the Earth, divides the heavens into two hemispheres, of which the upper one is called the visible hemisphere, and the lower one, the invisible hemisphere. It is the plane of this circle which determines the rising and setting of the heavenly bodies.

The *Sensible* or *Apparent Horizon*, is the circle which terminates our view, where the Earth and sky appear to meet.

To a person standing on a plain, this circle is but a few miles in diameter. If the eye be elevated five feet, the radius of the sensible horizon will be less than two miles and three quarters; if the eye be elevated six feet, it will be just three miles. The observer being always in the center of the sensible horizon, it will move as he moves, and enlarge or contract, as his station is elevated or depressed.

What expedient has been devised for designating, with precision, the situations of the heavenly bodies? What is the axis of the Earth? What are the poles of the Earth? What is the axis of the heavens? What are the poles of the heavens? What is the equator of the Earth? What is the equator of the heavens or the equinoctial? *What is a plane? What is the plane of a circle?* What is the rational horizon? What is the sensible or apparent horizon? *What is the diameter of this circle to a person standing on a plain? What will its radius be if the eye be elevated five feet? If it be elevated six feet? On what does the place of its center and its circumference depend*

The *Poles of the Horizon* are two points, of which the one is directly overhead, and is called the *Zenith;* the other is directly underfoot, and is called the *Nadir.*

Vertical Circles are circles drawn through the Zenith and Nadir of any place, cutting the horizon at right angles.

The *Prime Vertical* is that which passes through the east and west points of the horizon.

The *Ecliptic* is the great circle which the Sun appears to describe annually among the stars. It crosses the Equinoctial, a little obliquely, in two opposite points which are called the *Equinoxes.* The Sun rises in one of these points on the 21st of March; this point is called the *Vernal* Equinox. It sets in the opposite point on the 23d of September; this point is called the *Autumnal* Equinox. One half of the Ecliptic lies on the north side of the Equinoctial, the other half on the south side, making an angle with it of 23½°. This angle is called the *obliquity of the Ecliptic.* The axis of the Ecliptic makes the same angle with the axis of the heavens; so that the poles of each are 23½° apart.

This angle is perpetually decreasing. At the commencement of the Christian era, it was about 23° 45′. At the beginning of 1836, it was only 23° 27′ 38″, showing an annual diminution of about half a second, or 45″.70 in a hundred years. A time will arrive, however, when this angle, having reached its minimum, will again increase in the same ratio that it had before diminished, and thus it will continue to oscillate at long periods, between certain limits, which are said to be comprised within the space of 20° 42′.

The Ecliptic, like every other circle, contains 360°, and it is divided into 12 equal arcs of 30° each, called signs, which the ancients distinguished by particular names. This division commences at the vernal equinox, and is continued eastwardly round to the same point again, in the following order: *Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricornus, Aquarius, Pisces* The Sun, commencing at the first degree of Aries, about the 21st of March, passes, at a mean rate, through one sign every month.

The *Zodiac* is a zone or girdle, about 16 degrees in breadth, extending quite round the heavens, and including all the heavenly bodies within 8° on each side of the ecliptic. It includes, also, the orbits of all the planets, except some of the asteroids, since they are never seen beyond 8° either north or south of the ecliptic.

Parallels of Latitude are small circles imagined to be

What are the poles of the horizon? What are vertical circles? What is the prime vertical? What is the ecliptic? What are the equinoxes? The vernal equinox? The autumnal equinox? How is the ecliptic situated with respect to the equinoctial? What is the obliquity of the ecliptic? *Describe the manner in which this angle varies.* Describe the division of the ecliptic into signs. How much, at a mean rate, does the Sun advance in the ecliptic every month? What is the zodiac? What are parallels of latitude?

drawn on the Earth's surface, north and soath of the equator, and parallel to it.

Parallels of Declination are small circles, imagined to be drawn on the concave surface of the heavens, north and south of the equinoctial, and parallel to it; or they may be considered as circles formed by producing the parallels of latitude to the heavens.

The *Tropic of Cancer* is a small circle, which lies 23½° north of the Equinoctial, and parallel to it. The *Tropic of Capricorn* is a small circle, which lies 23½° south of the equinoctial, and parallel to it. On the *celestial* sphere, these two circles mark the limits of the Sun's farthest declination north and south. On the *terrestrial* sphere, they divide the torrid from the two temperate zones. That point in the ecliptic which touches the tropic of Cancer, is called the *Summer Solstice;* and that point in the ecliptic which touches the tropic of Capricorn, is called the *Winter Solstice.*

The distance of these two points from the equinoctial, is always equal to the obliquity of the ecliptic, which, in round numbers, is 23c°; but as we have seen the obliquity of the ecliptic is continually changing; therefore the position of the tropics must make a correspondent change.

The *Colures* are two great circles which pass through the poles of the heavens, dividing the ecliptic into four equal parts, and mark the seasons of the year. One of them passes through the equinoxes at Aries and Libra, and is thence called the *Equinoctial Colure;* the other passes through the solstitial points or the points of the Sun's greatest declination north and south, and is thence called the *Solstitial Colure.*

The Sun is in the equinoctial points the 21st of March and the 23d of September. He is in the solstitial points the 22d of June and the 22d of December.

The *Polar Circles* are two small circles, each about 66½° from the equator, being always at the same distance from the poles that the tropics are from the equator. The northern is called the *Arctic* circle, and the southern the *Antarctic* circle.

Meridians are imaginary great circles drawn through the poles of the world, cutting the equator and the equinoctial at right angles.

Every place on the Earth, and every corresponding point in the heavens, is considered as having a meridian passing through it; although astronomers apply

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What are parallels of declination? What is the Tropic of Cancer? What is the Tropic of Capricorn? What is the summer solstice? What is the winter solstice? *What is their distance from the equator, compared with the obliquity of the ecliptic? Is this distance always the same?* What are the colures? What is the equinoctial colure? What is the solstitial colure? On what days of the year is the sun in the equinoctial points? On what days is he in the solstitial points? What are the polar circles? By what names are they distinguished? What are meridians? *How many meridians are there? How many do astronomers apply to the heavens?*

but 24 to the heavens, thus dividing the whole concave surface into 24 sections, each 15° in width. These meridians mark the space which the heavenly bodies appear to describe, every hour, for the 24 hours of the day. They are thence sometimes denominated *Hour Circles.*

In measuring distances and determining positions on the Earth, the equator and some fixed meridian, as that of Greenwich, contain the primary starting points; in the heavens, these points are in the ecliptic, the equinoctial, and that great meridian which passes through the first point of Aries, called the equinoctial colure.

Latitude on the Earth, is distance north or south of the *equator*, and is measured on the meridian.

Latitude in the Heavens, is distance north or south of the *ecliptic*, and at right angles with it.

Longitude on the Earth, is distance either east or west from some fixed meridian, measured on the *equator.*

Longitude in the Heavens, is distance east from the first point of Aries, measured on the *ecliptic.*

Declination is the distance of a heavenly body either north or south of the equinoctial, measured on a meridian.

Right Ascension is the distance of a heavenly body east from the first point of Aries, measured on the equinoctial.

It is more convenient to describe the situation of the heavenly bodies by their declination and right ascension, than by their latitude and longitude, since the former corresponds to terrestrial latitude and longitude.

Latitude and declination may extend 90° and no more. Terrestrial longitude may extend 180° either east or west; but celestial longitude and right ascension, being reckoned in only one direction, extend entirely round the circle, or 360°.

In consequence of the Earth's motion eastward in its orbit, the stars seem to have a motion westward, besides their apparent diurnal motion caused by the Earth's revolution on its axis; so that they rise and set sooner every succeeding day by about four minutes, than they did on the preceding. This is called their daily acceleration. It amounts to just *two hours* a month.

EXAMPLE.—Those stars and constellations which do not rise until 10 o'clock this evening, will, at the same hour, one month hence, be 30° above the horizon; and, for the same reason, those stars which we see directly overhead this evening, will at the same hour, three months hence, be seen setting in the west; having in this time, performed one fourth of their apparent annual revolution.

The following table of *sidereal revolutions*, shows the difference between solar and sidereal time. The first column contains the numbers of complete revolutions of the stars, or of the Earth's rotation on its axis; the second exhibits the times in which these revolutions are made; and the third, shows how much the stars gain on the Sun every day—that is, how much sooner they rise and come to the meridian every succeeding day, than they did on the preceding.

Into how many sections do these meridians divide the concave surface of the heavens? Of what width are these sections? Why are these meridians sometimes called hour circles? In measuring distances on the Earth, what circles contain the primary starting points? Where are these points in measuring distances in the heavens? What is latitude on the Earth? What is latitude in the heavens? What is longitude on the Earth? What is longitude in the heavens? What is declination? What is right ascension? *Why is it more convenient to describe the situation of the heavenly bodies by their declination and right ascension, than by their latitude and longitude? How many degrees may latitude and declination extend? How many, terrestrial longitude? How many, celestial longitude?* What is meant by the daily acceleration of the stars? To how many minutes does it amount? *Illustrate this subject with an example.*

Revolutions of the Stars.	Times in which Revolutions are made.				Daily acceleration of the Stars.		
	days.	h.	min.	sec.	h.	min.	sec.
1	0	23	56	4	0	3	55
2	1	23	52	8	0	7	51
3	2	23	48	12	0	11	47
4	3	23	44	16	0	15	43
5	4	23	40	20	0	19	39
6	5	23	36	24	0	23	35
7	6	23	32	28	0	27	31
8	7	23	28	32	0	31	27
9	8	23	24	36	0	35	23
10	9	23	20	41	0	39	19
11	10	23	16	45	0	43	14
12	11	23	12	49	0	47	10
13	12	23	8	53	0	51	6
14	13	23	4	57	0	55	2
15	14	23	1	1	0	58	58
16	15	22	57	5	1	2	54
17	16	22	53	9	1	6	50
18	17	22	49	13	1	10	46
19	18	22	45	17	1	14	42
20	19	22	41	22	1	18	38
21	20	22	37	26	1	22	33
22	21	22	33	30	1	26	29
23	22	22	29	34	1	30	25
24	23	22	25	38	1	34	21
25	24	22	21	42	1	38	17
26	25	22	17	46	1	42	13
27	26	22	13	50	1	46	9
28	27	22	9	54	1	50	5
29	28	22	5	58	1	54	1
30	29	22	2	3	1	57	57
40	39	21	22	44	2	37	16
50	49	20	43	25	3	16	35
100	99	17	26	50	6	33	10
200	199	10	53	40	13	6	9
300	299	4	20	30	19	39	29
360	359	0	24	36	23	35	23
365	364	0	4	56	23	55	3
366	365	0	1	0	23	59	0

On this account, we have not always the same constellations visible to us throughout the year. While some, that were not visible before, are successively rising to view in the east, and ascending to the meridian, others sink beneath the western horizon, and are seen no more, until, having passed through the lower hemisphere, they again reappear in the east.

It is easy to convert right ascension into time, or time into right ascension, for if a heavenly body is one hour in passing over 15°, it will be one fifteenth of an hour. or 4 minutes, in passing over 1°.

If the first point of Aries be on the meridian at 12 o'clock, the next hour line, which is 15° E. of it, will come to the meridian at 1 o'clock; the second hour line at 2 o'clock; the third at 3, &c. Of any two bodies whose right ascensions are given, that one will pass the meridian *first* which has the *least* right ascension.

The first map of the atlas represents, upon a large scale, a general view of the solar system.

This will be more fully described in the Second Part of the work.

Do we always see the same constellations? *Explain the manner of converting right ascension into time, and time into right ascension.*

The next six maps represent different sections of the concave surface of the heavens. The first of these exhibits the principal constellations visible to us in October, November and December; the second, those visible in January, February and March; the third, those visible in April, May and June; and the fourth, those visible in July, August and September; with the exception, however, of the constellations which lie beyond the 50th degree of north and south declination, of which, indeed, those around the North Pole are *always*, and those around the South Pole, *never* visible to us.

These constellations are represented on the sixth and seventh maps, called circumpolar maps, which are an exact continuation of the others, and if joined to them at their corresponding degrees of right ascension and declination, they might be considered as constituting one map. The scale on which all the above-mentioned maps are drawn is that of a 16 inch globe. The lines drawn on the maps have been already defined; and their use, being nearly the same with those in Geography, will be readily understood. Those which are drawn from right to left, on each side of the equinoctial and parallel to it, are called *Parallels of Declination*. Those which are drawn up and down through the maps, at intervals of 15°, are called *Meridians of Right Ascension*, or *Hour Circles*. The scale at the top and bottom of the first four maps, and in the circumference of the circumpolar maps, indicates the daily progress of the stars in right ascension, and shows on what day of the month any star will be on the meridian at 9 o'clock in the evening.

The constellation called the Great Bear is an exception to this rule; in this constellation the principal stars are marked in the order of their right ascension.

That point of projection for the maps which would exhibit each successive portion of the heavens directly overhead at 9 o'clock in the evening, was chosen, because in summer at an earlier hour the twilight would bedim our observation of the stars, and at other seasons of the year it is easier to look up to stars that want an hour of their meridian altitude than to those which are directly overhead.

It will be readily seen that the stars are so represented on the maps as to show their relative magnitudes. The method invented by Bayer, of designating them by the letters of the Greek and Roman alphabets, is adopted. Thus in each constellation the stars are marked alpha, beta, &c., and should the letters of the Greek alphabet be exhausted, those of the Roman are employed. Some of the stars have also proper names.

The first four maps of the heavens are so constructed tha

For what months does the first map represent the heavens? For what months does the second map represent the heavens? The third? The fourth? What constellations are represented on the sixth and seventh maps? In what manner must these six maps be arranged to form one complete map of the heavens? On what scale are these maps drawn? What is the use of the scale at the top and bottom of the first four maps, and in the circumference of the circumpolar maps? *Why was that point of projection for the maps, which would represent each successive portion of the heavens directly overhead at 9 o'clock in the evening, chosen? What is the method by which the stars are designated on the maps?* How must the pupil, in using either of the first four maps imagine himself to stand and to hold it?

the pupil in using them must suppose himself to face the south, and to hold them directly overhead in such manner that the top of the map shall be towards the north, and the bottom towards the south; the right-hand side of the map will then be west, and the left-hand east. In using the circumpolar maps he must suppose himself to face the pole, and to hold them in such a manner that the day of the given month shall be uppermost. The Celestial Planisphere represents the whole heavens lying between 70 degrees of north and south declination, not as a surface of a concave sphere, but of a concave cylinder, and spread out so as to form a plain surface. A great variety of interesting problems, including almost all those that are peculiar to the celestial globe, may be solved upon it with facility and readiness.

We may now imagine the pupil ready to begin the study of the visible heavens. The first thing of importance is to fix upon the proper starting point. This, on many accounts, would seem to be the North Polar Star. Its position is apparently the same every hour of the night throughout the year, while the other stars are continually moving. Many of the stars also in that region of the skies never set, so that when the sky is clear, they may be seen at any hour of the night. They revolve about the pole in small circles, and never disappear below the horizon. On this account they are said to be within the circle of perpetual apparition. On the other hand, the identity of the North Polar Star, strange as it may appear, is not so easily determined by those who are just entering upon this study, as that of some others. For this reason, the point *directly overhead*, called the zenith, is preferable, since upon this point every one can fix with certainty in whatever latitude he may be. It will be alike to all the central point of the visible heavens, and to it the pupil will learn imperceptibly to refer the bearing, motion, and distances of the heavenly bodies.

That meridional point in each map, whose declination corresponds with the latitude of the place of observation, represents the zenith of the heavens at that place; and those constellations of stars which occupy this position on the maps, will be seen directly overhead at 9 o'clock in the evening of the day through which the meridian passes.—Thus in Georgia, for instance, the starting point should be those stars which are situated in this meridian near the 33d degree of north declination, while in New England it should be those which are situated in it near the 42d degree.

How, in using the circumpolar maps? Describe the construction and use of the Celestial Planisphere. When the pupil is ready to begin the study of the visible heavens, what is the first step to be taken? What advantages has the North Polar Star as a proper starting point? What disadvantages? What point is preferable to the Polar Star? Why is it preferable? *How may the point corresponding to this be found upon the maps? At what time in the evening will the stars which are near this point on the maps, be seen directly overhead?* Is it indispensably necessary to begin with the stars near this central meridian?

We *might*, however, begin with the stars near either of the meridians represented on the maps, the only rule of selection being to commence at that which approaches nearest to being overhead at the *time required*.

We have chosen for our starting point in this work that meridian which passes through the vernal equinox at the first point of Aries, not only because it is the meridian from which the distances of all the heavenly bodies are measured; but especially because the student will thus be enabled to observe and compare the progressive motion of the constellations according to the order in which they are always arranged in catalogues, and also to mark the constellations of the Zodiac passing overhead as they rise one after another in their order, and to trace among them the orbits of the Earth and of the other planets.

As Greek letters so frequently occur in catalogues and maps of the stars and on the celestial globes, the Greek alphabet is here introduced for the use of those who are unacquainted with it. The capitals are seldom used for designating the stars, but are here given for the sake of regularity.

THE GREEK ALPHABET.

Α	α	Alpha	a
Β	β	Beta	b
Γ	γ	Gamma	g
Δ	δ	Delta	d
Ε	ε	Epsilon	e short
Ζ	ζ	Zeta	z
Η	η	Eta	e long
Θ	θ	Theta	th
Ι	ι	Iota	i
Κ	κ	Kappa	k
Λ	λ	Lambda	l
Μ	μ	Mu	m
Ν	ν	Nu	n
Ξ	ξ	Xi	x
Ο	ο	Omicron	o short
Π	π	Pi	p
Ρ	ρ	Rho	r
Σ	ς	Sigma	s
Τ	τ	Tau	t
Υ	υ	Upsilon	u
Φ	φ	Phi	ph
Χ	χ	Chi	ch
Ψ	ψ	Psi	ps
Ω	ω	Omega	o long

In 1603, John Bayer, of Augsburg, in Germany, published a complete Atlas of all the constellations, with the useful invention of denoting the stars in every

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What is the only rule of selection? What is the starting point chosen for this work? What advantages has this meridian as a starting point?

constellation by the letters of the Greek and Roman Alphabets; assigning the Greek letter α to the principal stars in each constellation, β to the second in magnitude, γ to the third, and so on; and when the Greek alphabet was exhausted, the notation was carried on with the Roman letters, *a*, *b*, *c*, &c. That the memory might not be perplexed with a multitude of names, this convenient method of designating the stars has been adopted by all succeeding astronomers, who have farther enlarged it by the Arabic notation, 1, 2, 3, &c., whenever the stars in the constellations outnumbered both alphabets.

INCREASE OF SIDEREAL TIME IN MEAN SOLAR HOURS, &c.

	Increase.		Incr.		Incr.		Incr.		Incr.
Hours.	m. sec.	Min.	sec.	Min.	sec.	Sec.	sec.	Sec.	sec.
1	0 9.857	1	0.164	31	5.093	1	0.003	31	0.085
2	19.713	2	329	32	257	2	006	32	088
3	29.569	3	493	33	421	3	008	33	090
4	39.426	4	657	34	585	4	011	34	093
5	49.282	5	821	35	750	5	014	35	096
6	59.139	6	986	36	914	6	016	36	099
7	1 8.995	7	1.150	37	6.078	7	019	37	101
8	18.852	8	314	38	242	8	022	38	104
9	28.708	9	479	39	407	9	025	39	107
10	38.565	10	643	40	571	10	027	40	110
11	48.421	11	807	41	735	11	030	41	112
12	58.278	12	971	42	900	12	033	42	115
13	2 8.134	13	2.136	43	7.064	13	036	43	118
14	17.991	14	300	44	228	14	038	44	121
15	27.847	15	464	45	392	15	041	45	123
16	37.704	16	628	46	557	16	044	46	126
17	47.560	17	793	47	721	17	047	47	129
18	57.417	18	957	48	885	18	049	48	131
19	3 7.273	19	3.121	49	8.050	19	052	49	134
20	17.130	20	286	50	214	20	055	50	137
21	26.986	21	450	51	378	21	058	51	140
22	36.842	22	614	52	542	22	060	52	142
23	46.699	23	778	53	707	23	063	53	145
24	56.555	24	943	54	871	24	066	54	148
		25	4.107	55	9.035	25	069	55	151
		26	271	56	199	26	071	56	153
		27	435	57	364	27	074	57	156
		28	600	58	528	28	077	58	159
		29	764	59	692	29	079	59	162
		30	928	60	857	30	082	60	164

Daily acceleration of a star in passing the meridian,
m. sec.
3 55.9095

THE

GEOGRAPHY OF THE HEAVENS.

CHAPTER I.

DIRECTIONS FOR TRACING THE CONSTELLATIONS WHICH ARE ON THE MERIDIAN IN NOVEMBER.

ANDROMEDA.

If we look directly overhead at 10 o'clock, on the 10th of November, we shall see the constellation celebrated in fable by the name of ANDROMEDA. It is represented on the map by the figure of a woman having her arms extended, and chained by her wrists to a rock. It is bounded N. by Cassiopeia, E. by Perseus and the head of Medusa, and S. by the Triangles and the Northern Fish. It is situated between 20° and 50° of N. declination. Its mean right ascension is nearly 15°; or one hour E. of the equinoctial colure.

It consists of 66 visible stars, of which three are of the 2d magnitude, and two of the 3d; most of the rest are small.

The stars directly in the zenith are too small to be seen in the presence of the moon, but the bright star Almaack, of the 2d magnitude, in the left foot, may be seen 13° due E., and Merach, of the same magnitude, in the girdle, 7° south of the zenith. This star is then nearly on the meridian, and with two others N. W. of it forms the girdle.

The three stars forming the girdle are of the 2d, 3d, and 4th magnitude, situated in a row, 3° and 4° apart, and are called Merach, Mu and Nu.

About 2° from Nu at the north-western extremity of the girdle, is a remarkable nebula of very minute stars, and the only one of the kind which is ever visible to the naked eye. It resembles two cones of ligh t, joined at their base, about $\frac{3}{4}$° in length, and $\frac{1}{4}$° in breadth.

If we look directly overhead at 10 o'clock on the 10th of November, what constellation shall we see? How is it represented on the map? How is it bounded? Wha are its right ascension and declination? How many visible stars has it? Describe the girdle of Andromeda Describe the appearance of a remarkable nebula which lies at its north-western extremity.

If a straight line, connecting Almaack with Merach, be produced south-westerly, 8° farther, it will reach to *Delta*, a star of the 3d magnitude in the left breast. This star may be otherwise known by its forming a line, N. and S., with two smaller ones on either side of it; or, by its constituting, with two others, a very small triangle, S. of it.

Nearly in a line with Almaack, Merach and Delta, but curving a little to the N. 7° farther, is a lone star of the 2d magnitude, in the head, called Alpheratz. This is the N. E. corner of the great "Square of Pegasus," to be hereafter described.

It will be well to have the position of Alpheratz well fixed in the mind, because it is but one minute west of the great equinoctial colure. or first meridian of the heavens, and forms nearly a right line with Algenib in the wing of Pegasus, 14° S. of it, and with Beta in Cassiopeia, 30° N. of it. If a line, connecting these three stars, be produced, it will terminate in the pole. These three guides, in connection with the North Polar Star point out to astronomers the position of that great circle in the heavens from which the right ascension of all the heavenly bodies is measured.

History.—The story of Andromeda, from which this constellation derives its name, is as follows: She was daughter of Cepheus, king of Ethiopia, by Cassiopeia. She was promised in marriage to Phineus, her uncle. when Neptune drowned the kingdom, and sent a sea monster to ravage the country, to appease the resentment which his favorite Nymphs bore against Cassiopeia, because she had boasted herself fairer than Juno and the Nereides. The oracle of Jupiter Ammon was consulted, and nothing could pacify the anger of Neptune unless the beautiful Andromeda should be exposed to the sea monster. She was accordingly chained to a rock for this purpose, near Joppa. (now Jaffa, in Syria,) and at the moment the monster was going to devour her, Perseus, who was then returning through the air from the conquest of the Gorgons, saw her and was captivated by her beauty.

"Chained to a rock she stood; young Perseus stay'd
His rapid flight, to woo the beauteous maid."

He promised to deliver her and destroy the monster if Cepheus would give her to him in marriage. Cepheus consented, and Perseus instantly changed the sea monster into a rock, by showing him Medusa's head. which was still reeking in his hand. The enraged Phineus opposed their nuptials, and a violent battle ensued, in which he, also, was turned into a stone by the petrifying influence of the Gorgon's head.

The morals, maxims, and historical events of the ancients. were usually communicated in fable or allegory. The fable of Andromeda and the sea monster, might mean that she was courted by some monster of a sea-captain, who attempted to carry her away, but was prevented by another more gallant and successful rival.

PISCES.

The Fishes.—This constellation is now the first in order of the 12 constellations of the Zodiac, and is usually represented by two fishes tied a considerable distance apart, at the extremities of a long undulating cord, or ribbon. It occupies

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Describe the magnitude and position of Delta. How may this star be otherwise known? Describe the position and magnitude of Alpheratz. What position does this star occupy in the great Square of Pegasus? *Why is it important to have the position of this star well fixed in the mind?* What is the present order of the Fishes among the constellations of the Zodiac? How is it represented? Describe its outline and space in the heavens.

a large triangular space in the heavens, and its outline at first is somewhat difficult to be traced.

In consequence of the annual precession of the stars, the *constellation* Pisces has now come to occupy the *sign* Aries; each constellation having advanced one whole sign in the order of the Zodiac. The Sun enters the sign Pisces, while the Earth enters that of Virgo, about the 19th of February, but he does not reach the *constellation* Pisces before the 6th of March. The Fishes, therefore, are now called the "Leaders of the Celestial Hosts."—*See Aries.*

That loose assemblage of small stars directly south of Merach, in the constellation of Andromeda, constitutes the *Northern Fish*, whose mean length is about 16°, and breadth, 7°. Its mean right ascension is 15°, and its declination 25° N. Consequently, it is on the meridian the 24th of November; and from its breadth, is more than a week in passing over it. The Northern Fish and its ribbon, beginning at Merach, may by a train of small stars, be traced in a S. S. easterly direction, for a distance of 33°, until we come to the star El Rischa, of the 3d magnitude, which is situated in the node, or *flexure* of the ribbon. This is the principal star in the constellation, and is situated 2° N. of the equinoctial, and 53 minutes east of the meridian.

Seven degrees S. E. of El Rischa, passing by three or four very small stars we come to Mira, in the Whale, a star of about the 3d magnitude, and known as the "Wonderful Star of 1596." El Rischa may be otherwise identified by means of a remarkable cluster of five stars in the form of a *pentagon*, about 15° E. of it.—*See Cetus.*

From El Rischa the ribbon or cord makes a sudden flexure, doubling back across the ecliptic, where we meet with three stars of the fourth magnitude situated in a row 3° and 4° apart, marked on the map Zeta, Epsilon, Delta. From Delta the ribbon runs north and westerly along the Zodiac, and terminates at Beta, a star of the 4th magnitude, 11° S. of Markab in Pegasus.

This part of the ribbon including the Western Fish at the end of it, has a mean declination of 5° N., and may be seen throughout the month of November, passing the meridian slowly to the W., near where the sun passes it on the 1st of April. Twelve degrees W. of this Fish, there are 4 small stars situated in the form of the letter Y. The two Fishes, and the cord between them, make two sides of a large triangle, 30° and 40° in length, the open part of which is towards the N. W. When the Northern Fish is on the meridian,

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What are the size and position of the Northern Fish? When, and how long is it on the meridian? How may it be traced? What is the principal star in this constellation, and where is it situated? How far, and in what direction from Alpha, is Mira, in the Whale? By what peculiar apellation is this star known? What is the direction of the ribbon from Alpha? What stars do we meet with, where the ribbon doubles back across the ecliptic? What is the direction of this part of the ribbon from Delta, and where does it terminate? What are its mean declination, and the time of its passing the meridian? What striking cluster is seen about 12° W. of the Western Fish? What geometrical figure may be conceived to be formed by the two Fishes and the cord between them? Where is the Western Fish when the Northern is on the meridian?

the Western is nearly 2 hours past it. This constellation is bounded N. by Andromeda, W. by Andromeda and Pegasus, S. by the Cascade, and E. by the Whale, the Ram and the Triangles.

When, to enable the pupil to find any star, its direction from another is given, the latter is always understood to be on the meridian.

After a little experience with the maps, even though unaccompanied by directions, the ingenious youth will be able, of himself, to devise a great many expedients and facilities for tracing the constellations, or selecting out particular stars.

History.—The ancient Greeks, who have some fable to account for the origin of almost every constellation, say, that as Venus and her son Cupid were one day on the banks of the Euphrates, they were greatly alarmed at the appearance of a terrible giant, named Typhon. Throwing themselves into the river, they were changed into fishes, and by this means escaped danger. To commemorate this event, Minerva placed two fishes among the stars.

According to Ovid, Homer, and Virgil, this Typhon was a famous giant. He had a hundred heads, like those of a serpent or dragon. Flames of devouring fire darted from his mouth and eyes. He was no sooner born, than he made war against heaven, and so frightened the gods, that they fled and assumed different shapes. Jupiter became a ram; Mercury, an ibis; Apollo, a crow; Juno, a cow; Bacchus, a goat; Diana, a cat; Venus, a fish, &c. The father of the gods, at last, put Typhon to flight, and crushed him under Mount Ætna.

The obvious sentiment implied in the fable of this hideous monster, is evidently this: that there is in the world a description of men whose mouth is so "full of cursing and bitterness," derision and violence, that modest virtue is sometimes forced to disguise itself, or flee from their presence.

In the Hebrew Zodiac, Pisces is allotted to the escutcheon of Simeon.

No sign appears to have been considered of more malignant influence than *Pisces*. The astrological calendar describes the emblems of this constellation as indicative of violence and death. Both the Syrians and Egyptians abstained from eating fish, out of dread and abhorrence; and when the latter would represent any thing as odious, or express hatred by hieroglyphics, they painted a *fish*.

In using a circumpolar map, face the pole, and hold it up in your hands in such a manner that the part which contains the name of the given month shall be uppermost, and you will have a portraiture of the heavens as seen at that time.

The constellations about the Antarctic Pole are not visible in the United States; those about the Arctic or Northern Pole, are always visible.

CASSIOPEIA.

Cassiopeia is represented on the celestial map, in regal state seated on a throne or chair, holding in her left hand the branch of a palm tree. Her head and body are seen in the Milky Way. Her foot rests upon the Arctic Circle, upon which her chair is placed. She is surrounded by the chief personages of her royal family. The king, her husband, is on her right hand—Perseus, her son-in-law, on her left—and Andromeda, her daughter, just above her.

This constellation is situated 26° N. of Andromeda, and midway between it and the North Polar Star. It may be

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What are the boundaries of this constellation? How is the constellation Cassiopeia represented on the map? By whom is she surrounded? How is this constellation situated in regard to Andromeda and the Polar Star?

seen, from our latitude, at all hours of the night, and may be traced out at almost any season of the year. Its mean declination is 60° N. and its right ascension 12°. It is on our meridian the 22d of November, but does not sensibly change its position for several days; for it should be remembered that the apparent motion of the stars becomes slower and slower, as they approximate the poles.

Cassiopeia is a beautiful constellation, containing 55 stars that are visible to the naked eye; of which four are of the 3d magnitude, and so situated as to form, with one or two smaller ones, the figure of an inverted chair.

> ———"Wide her stars
> Dispersed, nor shine with mutual aid improved;
> Nor dazzle, brilliant with contiguous flame:
> Their number fifty-five."

Caph, in the garland of the chair, is almost exactly in the equinoctial colure, 30° N. of Alpheratz, with which, and the Polar Star, it forms a straight line. [*See note to Andromeda.*] Caph is therefore on the meridian the 10th of November, and one hour past it on the 24th. It is the westernmost star of the bright cluster. *Shedir**, in the breast, is the uppermost star of the five bright ones, and is 5° S. E. of Caph: the other three bright ones, forming the chair, are easily distinguished, as they meet the eye at the first glance.

There is an importance attached to the position of Caph that concerns the mariner and the surveyor. It is used, in connection with observations on the Polar Star, for determining the latitude of places, and for discovering the magnetic variation of the needle.

It is generally supposed that the North Polar Star, so called, is the real immovable pole of the heavens; but this is a mistake. It is *so near* the true pole that it has obtained the appellation of the *North Polar Star*; but it is, in reality, more than a *degree and a half* distant from it, and revolves about the true pole every 24 hours, in a circle whose radius is 1° 35′. It will consequently, in 24 hours, be twice on the meridian, once *above*, and once *below* the pole; and twice at its greatest elongation E. and W. [*See North Polar Star.*]

The Polar Star not being exactly in the N. pole of the heavens, but *one degree and* 35 *minutes* on that side of it which is towards Caph, the position of the latter becomes important, as it always shows on which side of the *true* pole the polar star is.

There is another important fact in relation to the position

* Shedir, from *El Seder*, the Seder tree; a name given to this constellation by Ulugh Beigh.

When may it be seen from this latitude? When is it on our meridian? How is the motion of the stars affected as they approach the poles? How many principal stars in this constellation, and what is their appearance? Describe the situation of Caph. When is Caph on the meridian? What is the relative position of Shedir? Why is the position of Caph important?

of this star. It is *equidistant* from the pole, and exactly *opposite* another remarkable star in the *square* of the Great Bear, on the other side of the pole. [*See Megrez.*] It also serves to mark a spot in the starry heavens, rendered memorable as being the place of a lost star. Two hundred and fifty years ago, a bright star shone 5° N. N. E. of Caph, where now is a dark void!

On the 8th of November, 1572, Tycho Brahe and Cornelius Gemma saw a star in the constellation of Cassiopeia, which became, all at once, so brilliant, that it surpassed the splendor of the brightest planets, and might be seen even at noonday Gradually, this great brilliancy diminished, until the 15th of March, 1573, when, without moving from its place, it became utterly extinct.

Its color, during this time, exhibited all the phenomena of a prodigious flame—first it was of a dazzling white, then of a reddish yellow, and lastly of an ashy paleness, in which its light expired. It is impossible, says Mrs. Somerville, to imagine any thing more tremendous than a conflagration that could be visible at such a distance. It was seen for sixteen months.

Some astronomers imagined that it would reappear again after 150 years; but it has never been discovered since. This phenomenon alarmed all the astronomers of the age, who beheld it; and many of them wrote dissertations concerning it.

Rev. Professor Vince, one of the most learned and pious astronomers of the age, has this remark:—"The disappearance of some stars may be the destruction of that system at the time appointed by the DEITY for the probation of its inhabitants; and the appearance of new stars may be the formation of new systems for new races of beings then called into existence to adore the works of their Creator."

Thus, we may conceive the Deity to have been employed from all eternity, and thus he may continue to be employed for endless ages; forming new systems of beings to adore him; and transplanting beings already formed into happier regions, who will continue to rise higher and higher in their enjoyments, and go on to contemplate system after system through the boundless universe.

LA PLACE says:—As to those stars which suddenly shine forth with a very vivid light, and then immediately disappear, it is extremely probable that great conflagrations, produced by extraordinary causes, take place on their surface. This conjecture, continues he, is confirmed by their change of color, which is analogous to that presented to us on the earth by those bodies which are set on fire and then gradually extinguished."

The late eminent Dr. Good also observes that—Worlds and systems of worlds

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What memorable spot does Caph serve to mark out? Describe the phenomenon of the lost star. What does Mrs. Somerville say of it? How long was it seen? Has any thing been discovered of it since? How did this phenomenon affect the astronomers of the age? What does Vince say of the disappearance of some stars, and the new appearance of others? *Repeat the observations of Dr. Good upon the subject of new stars appearing and disappearing* are not only perpetually creating, but also perpetually disappearing. It is an extraordinary fact, that within the period of the last century, not less than thirteen stars, in different constellations, seem to have totally perished, and ten new ones to have been created. In many instances it is unquestionable, that the stars themselves, the supposed habitation of other kinds or orders of intelligent beings, together with the different planets by which it is probable they were surrounded, have utterly vanished, and the spots which they occupied in the heavens, have become blanks! What has befallen other systems, will assuredly befall our own. Of the time and the manner we know nothing, but the fact is incontrovertible; it is foretold by revelation; it is inscribed in the heavens; it is felt through the earth. Such is the awful and daily text; what then ought to be the comment?

The great and good Beza, falling in with the superstition of his age, attempted to prove that this was a comet, or the same luminous appearance which conducted the magi, or wise men of the East, into Palestine, at the birth of our Saviour, and that it now appeared to announce his second coming!

About 6° N. W. of Caph, the telescope reveals to us a grand nebula of small stars, apparently compressed into one mass, or single blaze of light, with a great number of loose stars surrounding it.

History.—Cassiopeia was wife of Cepheus, king of Ethiopia, and mother of Andromeda. She was a queen of matchless beauty, and seemed to be sensible of it; for she even boasted herself fairer than Juno, the sister of Jupiter, or the Nereides—a name given to the sea nymphs. This so provoked the ladies of the sea that they complained to Neptune of the insult, who sent a frightful monster to ravage her coast, as a punishment for her insolence. But the anger of Neptune and the jealousy of the nymphs were not thus appeased. They demanded, and it was finally ordained that Cassiopeia should chain her daughter Andromeda, whom she tenderly loved, to a desert rock on the beach, and leave her exposed to the fury of this monster. She was thus left, and the monster approached; but just as he was going to devour her, Perseus killed him.

"The savior youth the royal pair confess.
And with heav'd hands, their daughter's bridegroom bless."
Eusden's Ovid

CEPHEUS.

Cepheus is represented on the map as a king, in his royal robe, with a scepter in his left hand, and a crown of stars upon his head. He stands in a commanding posture, with his left foot over the pole, and his scepter extended towards Cassiopeia, as if for favor and defence of the queen.

"Cepheus illumes
The neighboring heavens; still faithfu. to his queen,
With thirty-five faint luminaries mark'd."

This constellation is about 25° N. W. of Cassiopeia, near the 2d coil of Draco, and is *on* the meridian at 8 o'clock the 3d of November; but it will linger *near* it for many days. Like Cassiopeia, it may be seen at all hours of the night, when the sky is clear, for to us it never sets.

By reference to the lines on the map, which all meet in the pole, it will be evident that a star, near the pole, moves over a *much less* space in one hour, than

There is a remarkable nebula in this constellation; describe its situation and appearance. How is Cepheus represented? What is his posture? Where is this constellation situated one at the equinoctial; and generally, the *nearer* the pole, the *narrower* the space, and the *slower* the motion.

The stars that are so near the pole may be better described by their *polar distance*, than by their declination. By polar distance is meant, the *distance* from the pole, and is what the declination wants of 90°.

In this constellation there are 35 stars visible to the naked eye; of these, there glitters on the left shoulder, a star of the 3d magnitude, called *Alderamin*, which with two others of the same brightness, 8° and 12° apart, form a slightly-curved line towards the N. E. The last, whose *letter* name is Gamma, is in the right knee, 19° N. of Caph, in Cassiopeia. The middle one in the line, is Alphirk, in the girdle. This star is one third of the distance from Alderamin to the pole, and nearly in the same right line.

It cannot be too well understood that the bearings, or direction of one star from another, as given in this treatise, are strictly applicable only when the former one is on, or near the meridian. The bearings given, in many cases, are not the least approximations to what appears to be their relative position; and in some, if relied upon, will lead to errors. For example:—It is said, in the preceding paragraph, that Gamma, in Cepheus, bears 19° N. of Caph in Cassiopeia. This is true, when Caph is on the meridian, but at this very moment, while the author is writing this line, Gamma *appears* to be 19° *due west* of Caph; and six months hence, will appear to be the same distance *east* of it. The reason is obvious; the circle which Cepheus appears to describe about the pole, is *within* that of Cassiopeia, and consequently when on the east side of the pole, will be *within*, or *between* Cassiopeia and the pole—that is, *west* of Cassiopeia. And for the same reason, when Cepheus is on the west side of the pole, it is *between* that and Cassiopeia, or *east of it*.

Let it also be remembered, that in speaking of the *pole*, which we shall have frequent occasion to do, in the course of this work, the *North Polar Star* or an imaginary point very near it, is always meant; and *not* as some will vaguely apprehend, a point *in the horizon*, directly N. of us. The true pole of the heavens is always elevated just as many degrees *above* our horizon, as we are *north* of the Equator. If we live in 42° N. latitude, the N. pole will be 42° above our horizon. (*See North Polar Star.*)

There are also two smaller stars about 9° E. of Alderamin and Alphirk, with which they form a square; Alderamin being the upper, and Alphirk the lower one on the W. 8° apart. In the *center* of this square there is a bright dot, or semi-visible star.

The *head* of Cepheus is in the Milky-Way, and may be known by three stars of the 4th magnitude in the crown, which form a small acute triangle, about 9° to the right of Alderamin. The mean polar distance of the constellation is 25°, while that of Alderamin is 28° 10′. The right ascension of the former is 338°; consequently, it is 22° E. of the equinoctial colure.

The student will understand that right ascension is reckoned on the equinoctial, from the first point of Aries, E., quite round to the same point again, which

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How many, and what are the principal stars in it? Describe the last star in the curve. Describe the middle one. What four stars form a square in this constellation? Where is the head of Cepheus, and how may it be known? What is the mean polar distance of this constellation? How far, and which way is it from the equinoctial colure?

is 360°. Now 338°, measured from the same point, will reach the same point again, within 22°; which is the difference between 360° and 338°. This rule will apply to any other case.

HISTORY.—This constellation immortalizes the name of the king of Ethiopia. The name of his queen was Cassiopeia. They were the parents of Andromeda, who was betrothed to Perseus. Cepheus was one of the Argonauts who accompanied Jason on his perilous expedition in quest of the golden fleece. Newton supposes that it was owiug to this circumstance that he was placed in the heavens; and that not only this, but all the ancient constellations, relate to the Argonautic expedition, or to persons some way connected with it. Thus, he observes that as Musæus, one of the Argonauts, was the first Greek who made a celestial sphere, he would naturally delineate on it those figures which had some reference to the expedition Accordingly, we have on our globes to this day, the *Golden Ram*, the ensign of the ship in which Phryxus fled to Colchis, the scene of the Argonautic achievements. We have also the *Bull* with brazen hoofs, tamed by Jason; the *Twins*, Castor and Pollux, two sailors, with their mother *Leda*, in the form of a *Swan*, and *Argo*, the ship itself; the watchful *Dragon* Hydra, with the *Cup* of Medea, and a raven upon its carcass, as an emblem of death; also *Chiron*, the Master of Jason, with his *Altar*, and *Sacrifice; Hercules*, the Argonaut, with his *club*, his *dart*, and *vulture*, with the *dragon*, *crab* and *lion* which he slew; and *Orpheus*, one of the company, with his *harp*. All these, says Newton, refer to the Argonauts.

Again; we have *Orion*, the son of Neptune, or, as some say, the grandson of Minos, with his *dogs*, and *hare*, and *river*, and *scorpion*. We have the story of Perseus in the constellation of that name, as well as in Cassiopeia. Cepheus, Andromeda and Cetus; that of Calisto and her son Arcas, in *Ursa Major;* that of Icareus and his daughter Erigone, in *Bootes* and *Virgo*. *Ursa Minor* relates to one of the nurses of Jupiter; *Auriga*, to Erichthonius; *Ophiuchus*, to Phorbas; *Sagittarius*, to Crolus, the son of one of the Muses; *Capricorn*, to Pan, and *Aquarius* to Ganymede. We have also Ariadne's *crown*, Bellerophon's *horse*, Neptune's *dolphin*, Ganymede's *eagle*, Jupiter's *goat* with her *kids*, the asses of *Bacchus*, the *fishes* of Venus and Cupid, with their parent, the *southern fish*. These, according to Deltoton, comprise the Grecian constellations mentioned by the poet Aratus; and all relate, as Newton supposes, remotely or immediately, to the Argonauts.

It may be remarked, however, that while none of these figures refer to any transactions of a later date than the Argonautic expedition, yet the great disagreement which appears in the mythological account of them, proves that their invention must have been of greater antiquity than that event, and that these constellations were received for some time among the Greeks, before their poets referred to them in describing the particulars of that memorable expedition.

CHAPTER II.

DIRECTIONS FOR TRACING THE CONSTELLATIONS WHICH ARE ON THE MERIDIAN IN DECEMBER.

ARIES.

THE RAM.—Twenty-two centuries ago, as Hipparchus informs us, this constellation occupied the *first sign* in the ecliptic, commencing at the vernal equinox. But as the constellations gain about 50″ on the equinox, at every revolution of the heavens,* they have advanced in the ecliptic

* See "Precession of the Equinoxes," page 275.

What was the position of Aries in the ecliptic, 22 centuries ago?

nearly 31° beyond it, or more than a whole sign: so that the Fishes now occupy the same place in the Zodiac, that Aries did in the time of Hipparchus; while the *constellation* Aries is now in the *sign* Taurus, Taurus in Gemini, and Gemini in Cancer, and so on.

ARIES is therefore now the second constellation in the Zodiac. It is situated next east of Pisces, and is midway between the Triangles and the Fly on the N. and the head of Cetus on the S. It contains 66 stars, of which, one is of the 2d, one of the 3d, and two of the 4th magnitudes.

> "First, from the east, the Ram conducts the year;
> Whom Ptolemy with *twice nine* stars adorns,
> Of which two only claim the second rank;
> The rest, when Cynthia fills the sign, are lost."

It is readily distinguished by means of two bright stars in the head, about 4° apart, the brightest being the most north-easterly of the two. The first, which is of the 2d magnitude, situated in the right horn, is called Alpha Arietis, or simply *Arietis;* the other, which is of the 3d magnitude, lying near the left horn, is called Sheratan, and may be known by another star of the 4th magnitude, in the ear, 1½° S. of it, called *Mesarthim*, which is the *first* star in this constellation.

Arietis and Sheratan, are one instance out of many, where stars of more than ordinary brightness are seen together *in pairs*, as in the Twins, the Little Dog, &c., the brightest star being commonly on the east.

The position of Arietis affords important facilities to nautical science. Difficult to comprehend as it may be, to the unlearned, the skillful navigator who should be lost upon an unknown sea, or in the midst of the Pacific ocean, could, by measuring the distance between Arietis and the Moon, which often passes near it, determine at once not only the spot he was in, but his true course and distance to any known meridian or harbor on the earth.

Lying along the moon's path, there are nine conspicuous stars that are used by nautical men for determining their longitude at sea, thence called *nautical stars*.

These stars are *Arietis*, *Aldebaran*, *Pollux*, *Regulus*, *Spica Virginis*, *Antares*, *Altair*, *Fomalhaut*, and *Markab*.

The true places of these stars, for every day in the year, are given in the Nautical Almanac, a valuable work published annually by the English "Board of Admiralty," to guide mariners in navigating the seas. They are usually published two or three years in advance, for the benefit of long voyages.

That a man, says Sir John Herschel, by merely measuring the moon's apparent distance from a star, with a little portable instrument held in his hand, and

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What is its present position? How is it now situated with respect to the surrounding constellations? What are the number and magnitude of its stars? How is this constellation readily distinguished? Describe the two bright stars in the head. For what purposes is the position of some of the stars in Arietis important? How many stars are used for determining longitude at sea, and where are they situated? By what general name are they called? Enumerate them applied to his eye. even with so unstable a footing as the deck of a ship, shall say positively within five miles, where he is, on a boundless ocean, cannot but appear to persons ignorant of physical astronomy an approach to the miraculous. And yet, says he, the alternatives of life and death, wealth and ruin, are daily and hourly staked, with perfect confidence, on these marvelous computations.

Capt. Basil Hall. of the royal navy, relates that he had sailed from San Blas on the west coast of Mexico. and after a voyage of 8000 miles occupying eighty-nine days, arrived off Rio Janeiro, having in this interval passed through the Pacific ocean, rounded Cape Horn, and crossed the South Atlantic without making any land or seeing a single sail on the voyage. Arrived within a few days' sail of Rio, he took a set of lunar observations, to ascertain his true position, and the bearing of the harbor, and shaped his course accordingly. "I hove to," says he, "at 4 in the morning, till the day should break, and then bore up; for although it was hazy, we could see before us a couple of miles or so. About 8 o'clock it became so foggy that I did not like to stand in farther, and was just bringing the ship to the wind again before sending the people to breakfast when it suddenly cleared off, and I had the satisfaction of seeing the great Sugar-loaf rock, which stands on one side of the harbor's mouth, so nearly right ahead that we had not to alter our course above a point in order to hit the entrance of Rio. This was the first land we had seen for three months, after crossing so many seas, and being set backwards and forwards by innumerable currents and foul winds."

Arietis comes to the meridian about 12 minutes after Sheratan, on the 5th December, near where the sun does in midsummer. Arietis, also, is nearly on the same meridian with Almaack, in the foot of Andromeda, 19° N. of it, and culminates only four minutes after it. The other stars in this constellation are quite small, constituting that loose cluster which we see between the Fly on the north, and the head of Cetus on the south.

When Arietis is on the meridian, Andromeda and Cassiopeia are a little past the meridian, nearly overhead, and Perseus with the head of Medusa, is as far to the east of it. Taurus and Auriga are two or three hours lower down; Orion appears in the S. E., and the Whale on the meridian, just below Aries, while Pegasus and the Swan are seen half-way over in the west.

The manner in which the ancients divided the Zodiac into 12 equal parts, was both simple and ingenious. Having no instrument that would measure time exactly, "they took a vessel, with a small hole in the bottom, and having filled it with water, suffered the same to distill, drop by drop, into another vessel set beneath to receive it, beginning at the moment when some star rose, and continuing till it rose the next following night, when it would have performed one complete revolution in the heavens. The water falling down into the receiver they divided into 12 equal parts; and having twelve other small vessels in readiness, each of them capable of containing one part, they again poured all the water into the upper vessel, and observing the rising of some star in the Zodiac, at the same time suffered the water to drop into one of the small vessels. And as soon as it was full, they removed it, and set an empty one in its place. Just as each vessel was full, they took notice what star of the Zodiac rose at that time, and thus continued the process through the year, until the 12 vessels were filled."

Thus the Zodiac was divided into 12 equal portions, corresponding to the 12 months of the year, commencing at the vernal equinox. Each of these portions served as the visible representative or *sign* of the month it appeared in.

When does Arietis pass the meridian? What other brilliant star is on the meridian nearly at the same time? When Aries is on the meridian, what other constellations are immediately in view? *Describe the manner in which the ancients divided the Zodiac. At what point of the Zodiac did this division commence?*

All those stars in the Zodiac which were observed to rise while the first vessel was filling, were constellated and included in the first sign, and called *Aries*, an animal held in great esteem by the shepherds of Chaldea. All those stars in the Zodiac which rose while the second vessel was filling, were constellated and included in the second sign, which, for a similar reason, was denominated *Taurus* · and all those stars which were observed to rise while the third vessel was filling, were constellated in the *third* sign, and called Gemini, in allusion to the *twin season* of the flocks.

Thus each sign of 30° in the Zodiac, received a distinctive appellation, according to the fancy or superstition of the inventors; which names have ever since been retained, although the constellations themselves have since left their nominal signs more than 30° behind. The sign Aries, therefore, included all the stars embraced in the first 30° of the Zodiac, and no more. The sign Taurus, in like manner, included all those stars embraced in the next 30° of the Zodiac, or those between 30° and 60°, and so of the rest. Of those who imagine that the twelve constellations of the Zodiac refer to the twelve tribes of Israel, some ascribe Aries to the tribe of Simeon, and others, to Gad.

HISTORY.—According to fable, this is the ram which bore the golden fleece, and carried Phryxus and his sister Helle through the air, when they fled to Colchis from the persecution of their stepmother Ino. The rapid motion of the ram in his aerial flight high above the earth, caused the head of Helle to turn with giddiness, and she fell from his back into that part of the sea which was afterwards called *Hellespont*, in commemoration of the dreadful event. Phryxus arrived safe at Colchis, but was soon murdered by his own father-in-law, Ætes, who envied him his golden treasure. This gave rise to the celebrated Argonautic expedition under the command of Jason, for the recovery of the golden fleece.

Nephele, queen of Thebes, having provided her children, Phryxus and Helle, with this noble animal, upon which they might elude the wicked designs of those who sought their life, was afterwards changed into a cloud, as a reward for her parental solicitude; and the Greeks ever after called the clouds by her name. But the most probable account of the origin of this constellation is given in a preceding paragraph, where it is referred to the flocks of the Chaldean shepherds.

During the campaigns of the French army in Egypt, General Dessaix discovered among the ruins at Dendera, near the banks of the Nile, the great temple supposed by some to have been dedicated to Isis, the female deity of the Egyptians, who believed that the rising of the Nile was occasioned by the tears which she continually shed for the loss of her brother Osiris, who was murdered by Typhon.

Others suppose this edifice was erected for astronomical purposes, from the circumstance that *two Zodiacs* were discovered, drawn upon the ceiling, on opposite sides. On both these Zodiacs the equinoctial points are in Leo, and not in Aries; from which it has been concluded, by those who pertinaciously endeavor to array the arguments of science against the chronology of the Bible and the validity of the Mosaic account, that these Zodiacs were constructed when the sun entered the sign Leo, which must have been 9720 years ago, or 4000 years before the inspired account of the creation. The infidel writers in France and Germany make it 10,000 years before. But we may "set to our seal," that whatever is true in fact and correct in inference on this subject will be found, in the end, not only consistent with the Mosaic record, but with the common meaning of the expressions it uses.

The discovery of Champollion has put this question for ever at rest; and M. Latronne, a most learned antiquary, has very satisfactorily demonstrated that these Egyptian Zodiacs are merely the horoscopes of distinguished personages, or the precise situation of the heavenly bodies in the Zodiac at their nativity. The idea that such was their purpose and origin, first suggested itself to this gentleman on finding, in the box of a mummy, a similar Zodiac, with such inscriptions and characters as determined it to be the horoscope of the deceased person.

Of all the discoveries of the antiquary among the relics of ancient Greece, the

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What did each of these portions of the Zodiac serve? What stars were placed in the first sign? What name was given to the constellation thus formed? What stars were placed in the second sign? What was the second constellation called? What stars were placed in the third sign, and what was it called? Are the same names still retained? What does this precession, or going forward of the stars amount to in a year?

ruins of Palmyra, the gigantic pyramids of Egypt, the temples of their gods, or the sepulchres of their kings, scarcely one so aroused and riveted the curiosity of the learned, as did the discovery of Champollion the younger, which *deciphers the hieroglyphics* of ancient Egypt.

The potency of this invaluable discovery has already been signally manifested in settling a formidable controversy between the champions of infidelity and those who maintain the Bible account of the creation. It has been shown that the constellation *Pisces*, since the days of Hipparchus, has come, by reason of the annual precession, to occupy the same apparent place in the heavens that Aries did two thousand years ago. The Christian astronomer and the infidel are perfectly agreed as to the *fact*, and the *amount* of this yearly gain in the apparent motion of the stars. They both believe, and both can demonstrate, that the fixed stars have gone forward in the Zodiac about 50″ of a degree in every revolution of the heavens since the creation; so that were the world to light upon any authentic inscription or record of past ages, which should give the true position or longitude of any particular star at that time, it would be easy to fix an unquestionable date to such a record. Accordingly, when the famous "Egyptian Zodiacs," which were sculptured on the walls of the temple at Dendera, were brought away *en masse*, and exhibited in the Louvre at Paris, they enkindled a more exciting interest in the thousands who saw them, than ever did the entrance of Napoleon. "Educated men of every order, and those who had the vanity to think themselves such," says the commentator of Champollion, "rushed to behold *the Zodiacs*. These Zodiacs were immediately published and commented upon, with more or less good faith and decorum. Science struck out into systems very bold; and the spirit of infidelity, seizing upon the discovery, flattered itself with the hope of drawing from thence new support. It was unjustifiably taken for granted, that the ruins of Egypt furnished astronomy with monuments, containing observations that exhibited the state of the heavens in the most remote periods. Starting with this assumption, a pretence was made of demonstrating, by means of calculations received as infallible, that the celestial appearances assigned to these monuments extended back from forty-five to sixty-five centuries; that the Zodiacal system to which they must belong, dated back fifteen thousand years, and must reach far beyond the limits assigned by Moses to the existence of the world." Among those who stood forth more or less bold as the adversaries of Revelation, the most prominent was M. Dupuis, the famous author of *L' origine de tous les Cultes*.

The infidelity of Dupuis was spread about by means of pamphlets, and the advocates of the Mosaic account were scandalized "until a new Alexander arose to cut the Gordian knot, which men had vainly sought to untie. This was Champollion the younger, armed with his discovery." The hieroglyphics now speak a language that all can understand, and no one gainsay. "The Egyptian Zodiacs, then," says Latronne, "relate in no respect to astronomy, but to the idle phantasies of judicial astrology, as connected with the destinies of the emperors who made or completed them."

CETUS.

THE WHALE.—As the whale is the chief monster of the deep, and the largest of the aquatic race, so is it the largest constellation in the heavens. It occupies a space of 50° in length, E. and W., with a mean breadth of 20° from N. to S. It is situated below Aries and the Triangles, with a mean declination of 12° S. It is represented as making its way to the E., with its body below, and its head elevated above the equinoctial: and is six weeks in passing the meridian.

What is the comparative size of the Whale? What is its extent? Where is it situated? How long is the Whale in passing the meridian?

Its tail comes to the meridian on the 10th of November, and its head leaves it on the 22d of December.

This constellation contains 97 stars; two of the 2d magnitude, ten of the 3d, and nine of the 4th. The head of Cetus may be readily distinguished, about 20° S. E. of Aries, by means of five remarkable stars, 4° and 5° apart, and so situated as to form a regular pentagon. The brightest of these is Menkar, of the 2d magnitude, in the nose of the Whale. It occupies the S. E. angle of the figure. It is 3½° N. of the equinoctial, and 15° E. of El Rischa in the bight of the cord between the Two Fishes. It is directly 37° S. of Algol, and nearly in the same direction from the Fly. It makes an equilateral triangle with Arietis and the Pleiades, being distant from each about 23° S., and may otherwise be known by a star of the 3d magnitude in the mouth, 3° W. of it, called *Gamma*, placed in the south middle angle of the pentagon.

Nu is a star of the 4th magnitude, 4° N. W. of Gamma, and these two constitute the S. W. side of the pentagon in the head of the Whale, and the N. E. side of a similar oblong figure in the neck.

Three degrees S. S. W. of Gamma, is another star of the 3d magnitude in the lower jaw, marked Delta, constituting the E. side of the oblong pentagon; and 6° S. W. of this, is a noted star in the neck of the Whale, called *Mira*, or the "wonderful star of 1596," which forms the S. E. side. This variable star was first noticed as such by Fabricius, on the 13th of August, 1596. It changes from a star of the 2d magnitude so as to become invisible once in 234 days, or about 7 times in 6 years. Herschel makes its period 331 days, 10 hours, and 19 minutes; while Hevelius assures us that it once disappeared for 4 years; so that its true period, perhaps, has not been satisfactorily determined.

The whole number of stars ascertained to be variable amounts to only 15; while those which are suspected to be variable, amount to 37.

Mira is 7° S. S. E. of El Rischa, in the bend or knot of the ribbon which connects the Two Fishes. Ten degrees S. of Mira, are 4 small stars, in the breast and paws, about 3° apart, which form a square, the brightest being on the E.

When does it approach, and when does it leave the meridian? What is the whole number of stars in Cetus? What is the magnitude of the principal ones? How may the head of Cetus be distinguished? What are the name and position of the brightest? How far is it from the equinoctial, and the principal star in the Fishes? What is its direction from Algol and the Fly? With what stars does it form an equilateral triangle? How may it otherwise be known? Describe the position of Nu. Describe the situation of Delta and Mira. When and by whom was this star discovered to be variable? What are the extent and period of this variation? How long does Herschel make it? What does Hevelius say of it? Has the true period of Mira been satisfactorily determined? How far, and which way is Mira from Alpha, in the knot of the ribbon? What four small stars do you observe 10° S. of Mira?

Ten degrees S. W. of Mira, is a star of the 3d magnitude in the heart, called *Baten Kaitos*, which makes a scalene triangle with two other stars of the same magnitude 7° and 10° W. of it; also, an equilateral triangle with Mira and the easternmost one in the square.

A great number of geometrical figures may be formed from the stars in this, and in most of the other constellations, merely by reference to the maps: but it is better that the student should exercise his own ingenuity in this way with reference to the stars themselves, for when once he has constructed a group into any letter or figure of his own invention, he never will forget it.

The teacher should therefore require his class to commit to writing the result of their own observations upon the relative position. magnitude and figures of the principal stars in each constellation. One evening's exercise in this way will disclose to the student a surprising multitude of *crosses*, *squares*, *triangles*, *arcs* and *letters*, by which he will be better able to identify and remember them, than by any instructions that could be given.

For example: Mira and Baten in the Whale, about 10° apart, make up the S. E. or shorter side of an irregular square, with El Rischa in the node of the ribbon, and another star in the Whale as far to the right of Baten, as El Rischa is above Mira. Again,

There are three stars of equal magnitude, forming a straight line W. of Baten; from which, to the middle star is 10°, thence to the W. one 12½; and 8° or 9° S. of this line, in a triangular direction, is a bright star of the second magnitude in the coil of the tail, called Diphda.

In a southerly direction, 25° below Diphda, is Alpha in the head of the Phenix, and about the same distance S. W. is Fomalhaut, in the mouth of the Southern Fish, forming together a large triangle, with Diphda in the vertex or top of it.

That fine cluster of small stars S. of the little square in the Whale, constitutes a part of a new constellation called the *Chymical Furnace*. The two stars N. E. and the three to the southward of the little square, are in the river *Eridanus*.

HISTORY.—This constellation is of very early antiquity; though most writers consider it the famous sea-monster sent by Neptune to devour Andromeda because her mother Cassiopeia had boasted herself fairer than Juno or the Sea Nymphs; but slain by Perseus and placed among the stars in honor of his achievement.

"The winged hero now descends, now soars,
And at his pleasure the vast monster gores.
Deep in his back, swift stooping from above,
His crooked sabre to the hilt he drove."

It is quite certain, however, that this constellation had a place in the heavens long prior to the time of Perseus. When the equinoctial sun in Aries, which is right over the head of Cetus, opened the year, it was denominated the *Preserver*, or *Deliverer*, by the idolaters of the East. On this account, according to Pausanias, the sun was worshiped, at Eleusis, under the name of the *Preserver* or *Savior*.

"With gills pulmonic breathes the enormous whale,
And spouts aquatic columns to the gale;
Sports on the shining wave at noontide hours,
And shifting rainbows crest the rising showers."—*Darwin.*

PERSEUS, ET CAPUT MEDUSÆ.

PERSEUS is represented with a sword in his right hand, the head of Medusa in his left, and wings at his feet. It is situa-

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How is Baten Kaitos situated? *What is said of the various figures that different constellations exhibit? Give an example. Of what constellation does that fine cluster of stars of the little square in the Whale, constitute a part?* How is the constellation Perseus represented?

ted directly N. of the Pleiades and the Fly, between Andromeda on the W. and Auriga on the E. Its mean declination is 46° N. It is on the meridian the 24th of December. It contains, including the head of Medusa, 59 stars, two of which are of the 2d magnitude, and four of the 3d. According to Eudosia, it contains, including the head of Medusa, 67 stars.

> ——————" Perseus next,
> Brandishes high in heaven his sword of flame,
> And holds triumphant the dire Gorgon's head,
> Flashing with fiery snakes! the stars he counts
> Are *sixty-seven;* and two of these he boasts,
> Nobly refulgent in the *second* rank—
> One in his vest, one in Medusa's head."

The Head of Medusa is not a separate constellation, but forms a part of Perseus.

It is represented as the trunkless head of a frightful Gorgon, crowned with coiling snakes, instead of hair, which the victor Perseus holds in his hand.

There are, in all, about a dozen stars in the Head of Medusa; three of the 4th magnitude, and one, varying alternately from the 2d to the 4th magnitude. This remarkable star is called *Algol.* It is situated 12° E. of Almaack, in the foot of Andromeda, and may be known by means of three stars of the 4th magnitude, lying a few degrees S. W. of it, and forming a small triangle.

It is on the meridian the 21st of December; but as it continues above the horizon 18 hours out of 24, it may be seen every evening from September to May. It varies from the 2d to the 4th magnitude in about 3½ hours, and back again in the same time; after which it remains steadily brilliant for 2¾ days, when the same changes recur.

The periodical variation of Algol was determined in 1783, by John Goodricke of York, (Eng.,) to be 2 days, 20 hours, 48 minutes, and 56 seconds.

Dr. Herschel attributes the variable appearance of Algol to spots upon its surface, and thinks it has a motion on its axis similar to that of the *sun.* He also observes, of variable stars generally:—"The rotary motion of stars upon their axis is a capital feature in their resemblance to the sun. It appears to me now, that we cannot refuse to admit such a motion, and that indeed it may be as evidently proved as the

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Where is it situated? What is its declination, and when is it on the meridian? What is the whole number of its stars? What is the magnitude of its principal ones? Of what constellation does Caput Medusæ form a part? How is it represented? What is the whole number of its stars? What is the magnitude of the principal ones? What are the name and position of the variable star in this constellation? When is it on the meridian, and how long may it be seen? In what time does it vary from the 2d to the 4th magnitude, and back again? How long is it steadily brilliant? When and by whom was its periodical variation determined? What is its exact period? To what does Dr. Herschel attribute its variable appearance?

diurnal motion of the earth. Dark spots, or large portions of the surface less luminous than the rest, turned alternately in certain directions either toward, or from us, will account for all the phenomena of periodical changes in the luster of the stars, so satisfactorily, that we certainly need not look out for any other cause."

It is said, that the famous astronomer Lalande, who died at Paris in 1807, was wont to remain whole nights, in his old age, upon the *Pont Neuf*, to exhibit to the curious the variations in the brilliancy of the star Algol.

Nine degrees E. by N. from Algol, is the bright star *Algenib*, of the 2d magnitude, in the side of Perseus, which with Almaack, makes a perfect right angle at Algol, with the open part towards Cassiopeia. By means of this strikingly perfect figure, the three stars last mentioned may always be recognized without the possibility of mistaking them. Algenib may otherwise be readily distinguished by its being the brightest and middle one of a number of stars lying four and five degrees apart, in a large semicircular form, curving towards Ursa Major.

Algenib comes to the meridian on the 21st December, 15 minutes after Algol, at which time the latter is almost directly overhead. When these two stars are on the meridian, that beautiful cluster, the Pleiades, is about half an hour E. of it; and in short, the most brilliant portion of the starry heavens is then visible in the eastern hemisphere. The glories of the scene are unspeakably magnificent; and the student who fixes his eye upon those lofty mansions of being, cannot fail to covet a knowledge of their order and relations, and to "reverence Him who made the Seven Stars and Orion."

The Milky Way around Perseus is very vivid, being undoubtedly a rich stratum of fixed stars, presenting the most wonderful and sublime phenomenon of the Creator's power and greatness. Kohler, the astronomer, observed a beautiful nebula near the face of Perseus, besides eight other nebulous clusters in different parts of the constellation.

The head and sword of Perseus are exhibited on the circumpolar map. That very bright star 23° E. of Algol, is Capella in the Charioteer.

HISTORY.—Perseus was the son of Jupiter and Danae. He was no sooner born than he was cast into the sea with his mother; but being driven on the coasts of one of the islands of the Cyclades, they were rescued by a fisherman, and carried to Polydectes, the king of the place, who treated them with great humanity, and intrusted them to the care of the priests of Minerva's temple. His rising genius and manly courage soon made him a favorite of the gods. At a

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How may Algenib be distinguished? When is it on the meridian? How long after Algol? When these two stars are on the meridian, what beautiful cluster is half an hour east of it? What is the general appearance of the eastern hemisphere at that time? What is the appearance of the Milky Way around Perseus? What nebulæ have been observed in this constellation?

great feast of Polydectes, all the nobles were expected to present the king with a superb and beautiful horse; but Perseus, who owed his benefactor much, not wishing to be thought less munificent than the rest, engaged to bring him the head of Medusa, the only one of the three Gorgons who was subject to mortality. The names of the other two were Stheno and Euryale. They were represented with serpents wreathing round their heads instead of hair, having yellow wings and brazen hands; their bodies which grew indissolubly together were covered with impenetrable scales, and their very looks had the power of turning into stones all those on whom they fixed their eyes.

To equip Perseus for this perilous enterprise, Pluto, the god of the infernal regions, lent him his helmet, which had the power of rendering the wearer invisible. Minerva the goddess of wisdom, furnished him with her buckler, which was as resplendent as a polished mirror; and he received from Mercury wings for his feet, and a dagger made of diamonds. Thus equipped, he mounted into the air, conducted by Minerva, and came upon the monsters who, with the watchful snakes about their heads, were all asleep. He approached them, and with a courage which amazed and delighted Minerva, cut off with one blow Medusa's head. The noise awoke the two immortal sisters, but Pluto's helmet rendered Perseus invisible, and the vengeful pursuit of the Gorgons proved fruitless.

> "In the mirror of his polished shield
> Reflected, saw Medusa slumbers take,
> And not one serpent by good chance awake;
> Then backward an unerring blow he sped,
> And from her body lopped at once her head."

Perseus then made his way through the air, with Medusa's head yet reeking in his hand, and from the blood which dropped from it as he flew, sprang all those innumerable serpents that have ever since infested the sandy deserts of Libya.

> "The victor Perseus, with the Gorgon head,
> O'er Libyan sands his airy journey sped,
> The gory drops distilled, as swift he flew,
> And from each drop envenomed serpents grew."

The destruction of Medusa rendered the name of Perseus immortal, and he was changed into a constellation at his death, and placed among the stars, with the head of Medusa by his side.

CHAPTER III.

DIRECTIONS FOR TRACING THE CONSTELLATIONS WHICH ARE ON THE MERIDIAN IN JANUARY.

The constellations which pass our meridian in the months of January, February and March, present to us the most brilliant and interesting portion of the heavens; embracing an annual number of stars of the highest order and brightness, all so conspicuously situated, that the most inexperienced can easily trace them out.

TAURUS.

THE BULL is represented in an attitude of rage, as if about to plunge at Orion, who seems to invite the onset by provocations of assault and defiance. Only the head and shoulders of the animal are to be seen; but these are so distinctly marked

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What is the comparative brilliancy of the constellations which pass the meridian in January, February and March? How is Taurus represented? What parts of the animal are to be seen?

that they cannot be mistaken. Taurus is now the *second sign* and *third constellation* of the Zodiac; but anterior to the time of Abraham, or more than 4000 years ago, the vernal equinox took place, and the year opened when the sun was in Taurus; and the Bull, for the space of 2000 years, was the prince and leader of the celestial host. The Ram succeeded next, and now the Fishes lead the year. The head of Taurus sets with the sun about the last of May, when the opposite constellation, the Scorpion, is seen to rise in the S. E. It is situated between Perseus and Auriga on the north, Gemini on the east, Orion and Eridanus on the south, and Aries on the west, having a mean declination of 16° N.

It contains 141 visible stars, including two remarkable clusters called the PLEIADES and HYADES. The first is now on the shoulder, and the latter in the face of the Bull.

The Pleiades, according to fable, were the seven daughters of Atlas and the nymph Pleione,* who were turned into stars, with their sisters the Hyades, on account of their amiable virtues and mutual affection.

Thus we every where find that the ancients, with all their barbarism and idolatry, entertained the belief that unblemished virtue and a meritorious life would meet their reward in the sky. Thus Virgil represents Magnus Apollo as bending from the sky to address the youth Iulus:—

"Macte nova virtute puer; sic itur ad astra;
Diis genite, et geniture Deos."

"Go on, spotless boy, in the paths of virtue; it is the way to the stars; offspring of the gods thyself—so shalt thou become the father of gods."

Our disgust at their superstitions may be in some measure mitigated, by seriously reflecting, that had some of these personages lived in our day, they had been ornaments in the Christian church, and models of social virtue.

The names of the Pleiades are Alcione, Merone, Maia, Electra, Tayeta, Sterope and Celeno. Merope was the only one who married a mortal, and on that account her star is dim among her sisters.

Although but six of these are visible to the naked eye, yet Dr. Hook informs us that, with a twelve feet telescope, he saw 78 stars; and Rheita affirms that he counted 200 stars in this small cluster.

The most ancient authors, such as Homer, Attalus, and Geminus, counted only *six* Pleiades; but Simonides, Varro, Pliny, Aratus, Hipparchus, and Ptolemy, reckon them seven in number; and it was asserted, that the seventh had been seen before the burning of Troy; but this difference might arise from the difference in distinguishing them with the naked eye.

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* Dr. Hutton is of opinion that Atlas being the first astronomer who discovered these stars, called them by the names of the daughters of his wife Pleione.

What is the numerical order of Taurus among the signs and constellations of the Zodiac? What was its position in the Zodiac before the time of Abraham? How long did it continue to lead the celestial host? What constellation succeeded next? Where is Taurus now situated? How many stars does it contain? What remarkable clusters are in this constellation? Where are these placed? Mention the names of the Pleiades. Which of these seven stars is not seen, and why? Are these six all that can be seen through the telescope?

The Pleiades are so called from the Greek word, πλεειν *pleein*, to *sail;* because, at this season of the year, they were considered "the star of the ocean" to the benighted mariner.* *Alcyone*, of the 3d magnitude, being the brightest star in this cluster, is sometimes called the *light of the Pleiades.* The other five are principally of the 4th and 5th magnitudes.

The Pleiades, or, as they are more familiarly termed, the *seven stars*, come to the meridian 10 minutes before 9 o'clock, on the evening of the 1st of January, and may serve, in place of the sun, to indicate the time, and as a guide to the surrounding stars.

According to Hesiod, who wrote about 900 years before the birth of our Saviour, the heliacal rising of the Pleiades took place on the 11th of May, about the time of harvest.

"When, Atlas-born, the Pleiad stars arise
Before the sun above the dawning skies,
'Tis time to reap; and when they sink below
The morn-illumin'd west, 'tis time to sow."

Thus, in all ages, have the stars been observed by the husbandman, for "signs and for seasons."

Pliny says that Thales, the Miletan astronomer, determined the cosmical setting of the Pleiades to be 25 days after the autumnal equinox. This would make a difference between the setting at that time and the present, of 35 days, and as a day answers to about 59′ of the ecliptic, these days will make 34° 25′. This divided by the annual precession ($50\frac{1}{4}''$), will give 2465 years since the time of Thales. Thus does astronomy become the parent of chronology.

If it be borne in mind that the stars uniformly rise, come to the meridian, and set about four minutes earlier every succeeding night, it will be very easy to determine at what time the seven stars pass the meridian on any night subsequent or antecedent to the 1st of January. For example: at what time will the

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* Virgil, who flourished 1200 years before the invention of the magnetic needle, says that the stars were relied upon, in the first ages of nautical enterprise, to guide the rude bark over the seas.

"Tunc alnos primum fluvii sensere cavatas;
Navita tum stellis numeros, et nomina fecit,
Pleiadas, Hyadas, claramque Lycaonis Arcton."

"Then first on seas the shallow alder swam;
Then sailors quarter'd heaven, and found a name
For every fix'd and every wand'ring star—
The Pleiades, Hyades, and the Northern Car."

The same poet also describes Palinurus, the renowned pilot of the Trojan fleet, as watching the face of the nocturnal heavens.

"Sidera cuncta notat tacito labentia cœlo,
Arcturum, pluviasque Hyadas, geminosque Triones,
Armatumque auro circumspicit Oriona."

"Observe the stars, and notes their sliding course,
The Pleiades, Hyades, and their wat'ry force;
And both the Bears is careful to behold,
And bright Orion, arm'd with burnish'd gold."

Indeed, this sagacious pilot was once so intent in gazing upon the stars while at the helm, that he fell overboard, and was lost to his companions.

"Headlong he fell, and struggling in the main,
Cried out for helping hands, but cried in vain."

From what circumstance do the Pleiades derive their name? What is the brightest of the Pleiades called? What is the size of the rest? When are the Pleiades on the meridian? *How much earlier do the stars rise, come to the meridian, and set, every succeeding night?*

seven stars culminate on the 5th of January? Multiply the 5 days by 4 and take the result from the time they culminate on the 1st, and it will give 30 minutes after 8 o'clock in the evening.

The Pleiades are also sometimes called *Vergiliæ*, or the "Virgins of spring;" because the sun enters this cluster in the "season of blossoms," about the 18th of May. He who made them alludes to this circumstance when he demands of Job: "Canst thou bind the sweet influences of the Pleiades," &c.—[Job 38 : 31.]

The Syrian name of the Pleiades is *Succoth*, or *Succoth-Benoth*, derived from a Chaldaic word, which signifies "to speculate, to observe," and the "Men of Succoth" (2 Kings 17 : 30) have been thence considered observers of the stars.

The *Hyades* are situated 11° S. E. of the Pleiades, in the face of the Bull, and may be readily distinguished by means of five stars* so placed as to form the letter V. The most brilliant star is on the left, in the top of the letter, and called *Aldebaran;* from which the moon's distance is computed.

"A star of the first magnitude illumes
His radiant head; and of the second rank.
Another beams not far remote."

Aldebaran is of Arabic origin, and takes its name from two words which signify, "He went before, or led the way"—alluding to that period in the history of astronomy when this star led up the starry host from the vernal equinox. It comes to the meridian at 9 o'clock on the 10 of January, or 48½ minutes after Alycone, on the 1st. When Aries is about 27° high, Aldebaran is just rising to the east. So MANILIUS:—

"Thus when the *Ram* hath doubled ten degrees,
And join'd seven more, then rise the Hyades."

A line 15½° E. N. E. of Aldebaran will point out a bright star of the 2d magnitude in the extremity of the northern horn, marked Beta or El Nath; (this star is also in the foot of Auriga, and is common to both constellations.) From Beta in the northern horn, to Zeta, in the tip of the southern horn, it is 8°, in a southerly direction. This star forms a right angle with Aldebaran and Beta. Beta and Zeta, then, in the button of the horns, are in a line nearly north and south, 8° apart, with the brightest on the north. That very bright star 17½° N. of Beta, is *Capella*, in the constellation *Auriga.*

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* The ancient Greeks counted seven in this cluster:—
"The Bull's head shines with seven refulgent flames,
Which, *Grecia*, Hyades, from their *showering*, names."

At what time will the seven stars culminate on the 5th January? By what other names are they sometimes called, and why? What allusion is made to this cluster in the ancient Scriptures? Describe the situation and appearance of the Hyades. What is the brightest of them called? What is the origin of the word Aldebaran, and to what does it allude? When does Aldebaran culminate? Describe the position of Beta. What are the name and direction of the star in the southern horn? What is the relative position of these stars? What very bright star is seen 17° 30′ N. of Beta?

HISTORY.—According to the Grecian mythology, this is the animal which bore Europa over the seas to that country which derived from her its name. She was the daughter of Agenor, and princess of Phœnicia. She was so beautiful that Jupiter became enamored of her; and assuming the shape of a snow-white bull, he mingled with the herds of Agenor, while Europa, with her female attendants, were gathering flowers in the meadows. Europa caressed the beautiful animal, and at last had the courage to sit upon his back. The god now took advantage of her situation, and with precipitate steps retired towards the shore, and crossed the sea with Europa upon his back, and arrived safe in Crete. Some suppose she lived about 1552 years before the Christian Era. It is probable, however, that this constellation had a place in the Zodiac before the Greeks began to cultivate a knowledge of the stars; and that it was rather an invention of the Egyptians or Chaldeans. Both the Egyptians and Persians worshiped a deity under this figure, by the name of Apis; and Belzoni is said to have found an embalmed bull in one of the notable sepulchres near Thebes.

In the Hebrew Zodiac, Taurus is ascribed to Joseph.

ORION.

Whoever looks up to this constellation and learns its name, will never forget it. It is too beautifully splendid to need a description. When it is on the meridian, there is then above the horizon the most magnificent view of the celestial bodies that the starry firmament affords; and it is visible to all the habitable world, because the equinoctial passes through the middle of the constellation. It is represented on celestial maps by the figure of a man in the attitude of assaulting the Bull, with a sword in his belt, a huge club in his right hand, and the skin of a lion in his left, to serve for a shield.

Manilius, a Latin poet, who composed five books on astronomy a short time before the birth of our Saviour, thus describes its appearance:—

"First next the Twins, see great *Orion* rise,
His arms extended stretch o'er half the skies;
His stride as large, and with a steady pace
He marches on, and measures a vast space;
On each broad shoulder a bright star display'd,
And three obliquely grace his hanging blade.
In his vast head, immers'd in boundless spheres,
Three stars, less bright, but yet as great, he bears,
But farther off removed, their splendor's lost;
Thus graced and arm'd he leads the starry host."

The center of the constellation is midway between the poles of the heavens and directly over the equator. It is also about 8° W. of the solstitial colure, and comes to the meridian about the 23d of January. The whole number of visible stars in this constellation is 78; of which, two are of the first magnitude, four of the 2d, three of the 3d, and fifteen of the 4th.

Those four brilliant stars in the form of a long square or

What is the general appearance of the constellation Orion? When this constellation is on the meridian, what is the appearance of the starry firmament? To whom is it visible, and why? How is Orion represented on celestial maps? Describe its position. How is it situated with respect to the solstitial colure, and when is it on the meridian? What remarkable stars form the outlines of the constellation?

parallelogram, intersected in the middle by the "Three Stars," or "Ell and Yard," about 25° S. of the Bull's horns, form the outlines of Orion. The two upper stars in the parallelogram are about 15° N. of the two lower ones; and, being placed on each shoulder, may be called the epaulets of Orion. The brightest of the two lower ones is in the left foot, on the W., and the other, which is the least brilliant of the four, in the right knee. To be more particular; Bellatrix is a star of the 2d magnitude on the W. shoulder; Betelguese is a star of the 1st magnitude, 7½° E. of Bellatrix, on the E. shoulder. It is brighter than Bellatrix, and lies a little farther toward the north; and comes to the meridian 30 minutes after it, on the 21st of January. These two form the upper end of the parallelogram.

Rigel is a splendid star of the 1st magnitude, in the left foot, on the W. and 15° S. of Bellatrix. *Saiph* is a star of the 3d magnitude, in the right knee, 8½° E. of Rigel. These two form the lower end of the parallelogram.

——————"First in rank
The martial star upon his shoulder flames;
A rival star illuminates his foot;
And on his girdle beams a luminary
Which, in vicinity of other stars,
Might claim the proudest honors."

There is a little triangle of three small stars in the head of Orion, which forms a larger triangle with the two in his shoulders. In the middle of the parallelogram are three stars of the 2d magnitude, in the belt of Orion, that form a straight line about 3° in length from N. W. to S. E. They are usually distinguished by the name of the *Three Stars*, because there are no other stars in the heavens that exactly resemble them in position and brightness. They are sometimes denominated the *Three Kings*, because they point out the Hyades and Pleiades on one side, and Sirius, or the Dog-star, on the other. In Job they are called the *Bands of Orion;* while the ancient husbandmen called them *Jacob's rod*, and sometimes the *Rake*. The University of Leipsic, in 1807, gave them the name of *Napoleon*. But the more common appellation for them, including those in the sword, is the *Ell and Yard*. They derive the *latter* name from the circumstance that the line which unites the "three stars" in the belt measures just 3° in length, and is divided by the central star

Describe the two upper ones in the group. Describe the two lower ones. Give a more particular description of the stars in the shoulder. How do you distinguish Betelguese from Bellatrix? When does Betelguese come to the meridian? Describe the stars which form the lower end of the parallelogram. What stars do you observe in the head of Orion? Describe the situation and appearance of the "Three Stars." Why are they called the three stars? What else are they denominated, and why? What names were given to them by the ancients? What by the University of Leipsic? What is the more familiar term for them, and whence is it derived?

into two equal parts, like a yard-stick; thus serving as a graduated standard for measuring the distances of stars from each other. When, therefore, any star is described as being so many degrees from another, in order to determine the distance, it is recommended to apply this rule.

It is necessary that the scholar should task his ingenuity only a few evenings in applying such a standard to the stars, before he will learn to judge of their relative distances with an accuracy that will seldom vary a degree from the truth.

The northernmost star in the belt, called *Mintika*, is less than ½° S. of the equinoctial, and when on the meridian, is almost exactly over the equator. It is on the meridian, the 24th. of January.*

The "three stars" are situated about 8° W. of the solstitial colure, and uniformly pass the meridian one hour and fifty minutes after the seven stars.

There is a row of stars of the 4th and 5th magnitudes, S. of the belt, running down obliquely towards Saiph, which forms the sword. This row is also called the *Ell* because it is once and a quarter the length of the *Yard* or belt.

A very little way below Thabit, in the sword, there is a nebulous appearance, the most remarkable one in the heavens. With a good telescope an apparent opening is discovered, through which, as through a window, we seem to get a glimpse of other heavens, and brighter regions beyond.

As the telescope extends our knowledge of the stars and greatly increases their visible nnmber, we behold hundreds and thousands, which, but for this almost divine improvement of our vision, had forever remained, unseen by us, in an unfathomable void.

A star in Orion's sword, which appears single to the unassisted vision, is multiplied into six by the telescope; and another, into twelve. Galileo found 80 in the belt, 21 in a nebulous star in the head, and about 500 in another part of Orion, within the compass of one or two degrees. Dr. Hook saw 78 stars in the Pleiades, and Rheita, with a better telescope, saw about 200 in the same cluster and more than 2000 in Orion.

About 9° W. of Bellatrix are eight stars, chiefly of the 4th magnitude, in a curved line running N. and S. with the concavity toward Orion; these point out the skin of the lion in his left hand. Of Orion, on the whole, we may remark with Eudosia:—

"He who admires not, to the stars is blind."

HISTORY.—According to some authorities, Orion was the son of Neptune and queen Euryale, a famous Amazonian huntress, and possessing the disposition of

* Though the position of this star, with respect to the equator, is the same at all times whether it be on the meridian or in the horizon; yet it *appears* to occupy this position, only, when it is on the meridian.

How may the distances of the stars from each other be measured by reference to the Yard? How are the three stars situated with respect to the solstitial colure, and how with respect to the seven stars? Describe the stars which form the sword of Orion What else is this row called? Describe the nebulous appearance which is visible in this cluster. *What other discoveries has the telescope made in this constellation?* What stars about 9° W. of Bellatrix?

his mother, he became the greatest hunter in the world, and even boasted that there was not an animal on earth which he could not conquer. To punish this vanity, it is said that a scorpion sprung up out of the earth and bit his foot, that he died; and that at the request of Diana he was placed among the stars directly opposite to the Scorpion that caused his death. Others say that Orion had no mother, but was the gift of the gods, Jupiter, Neptune, and Mercury, to a peasant of Bœotia, as a reward of piety, and that he was invested with the power of walking over the sea without wetting his feet. In strength and stature he surpassed all other mortals. He was skilled in the working of iron, from which he fabricated a subterranean palace for Vulcan; he also walled in the coasts of Sicily against the inundations of the sea, and built thereon a temple to its gods.

Orion was betrothed to the daughter of Œnopion, but he, unwilling to give up his daughter, contrived to intoxicate the illustrious hero and put out his eyes on the seashore where he had laid himself down to sleep. Orion, finding himself blind when he awoke, was conducted by the sound to a neighboring forge, where he placed one of the workmen on his back, and, by his directions, went to a place where the rising sun was seen with the greatest advantage. Here he turned his face toward the luminary, and, as it is reported, immediately recovered his sight, and hastened to punish the perfidious cruelty of Œnopion.

The daughters of Orion distinguished themselves as much as their father; and, when the oracle had declared that Bœotia should not be delivered from a dreadful pestilence, before two of Jupiter's children were immolated on the altars, they joyfully accepted the offer, and voluntarily sacrificed themselves for the good of their country. The deities of the infernal regions were struck at the patriotism of the two females, and immediately two stars were seen to ascend up from the earth, still smoking with their blood, and they were placed in the heavens in the form of a crown. Ovid says their bodies were burned by the Thebans, and that two persons arose from their ashes, whom the gods soon after changed into constellations.

As the constellation Orion, which rises at noon about the 9th day of March, and sets at noon about the 21st of June, is generally supposed to be accompanied, at its rising, with great rains and storms, it became extremely terrible to mariners, in the early adventures of navigation. Virgil, Ovid, and Horace, with some of the Greek poets, make mention of this.

Thus Eneas accounts for the storm which cast him on the African coast on his way to Italy:—

"To that blest shore we steer'd our destined way,
When sudden, dire *Orion* rous'd the sea;
All charg'd with tempests rose the baleful star,
And on our navy pour'd his wat'ry war."

To induce him to delay his departure, Dido's sister advises her to

"Tell him, that, charg'd with deluges of rain,
Orion rages on the wintry main."

The name of this constellation is mentioned in the books of Job and Amos, and in Homer. The inspired prophet, penetrated like the psalmist of Israel with the omniscience and power displayed in the celestial glories, utters this sublime injunction: "Seek Him that maketh the seven stars and Orion, and turneth the shadow of death into morning." Job also, with profound veneration, adores His awful majesty who "commandeth the sun and sealeth up the stars; who alone spreadeth out the heavens, and maketh Arcturus, Orion, and Pleiades, and the chambers of the south:" and in another place, the Almighty demands of him—"Knowest thou the ordinances of heaven? Canst thou bind the sweet influences of the Pleiades, or loose the bands of Orion; canst thou bring forth Mazzaroth in his season, or canst thou guide Arcturus with his sons?"

Calmet supposes that *Mazzaroth* is here put for the whole order of celestial bodies in the Zodiac, which, by their appointed revolutions, produce the various seasons of the year, and the regular succession of day and night. *Arcturus* is the name of the principal star in Bootes, and is here put for the constellation itself. The expression, *his sons*, doubtless refers to Asterion and Chara, the two greyhounds, with which he seems to be pursuing the Great Bear around the North pole.

The following lines are copied from a work entitled "Astronomical Recreations," by J. Green, of Pennsylvania, to whom the author is indebted for many valuable hints concerning the mythology of the ancient constellations.

"When chilling winter spreads his azure skies.
Behold *Orion's* giant form arise;
His *golden girdle* glitters on the sight;
And the *broad falchion* beams in splendor bright;
A *lion's brindled hide* his bosom shields,
And his right hand a *ponderous weapon* wields.

The *River's* shining streams beneath him pour.
And angry *Taurus* rages close before;
Behind him *Procyon* barks, and *Sirius* growls,
While full in front, the *monster Cetus* howls.

See bright *Capella*, and *Medusa* there,
With horrid *serpents* hissing through her hair;
See *Cancer* too, and near the *Hydra* dire,
With roaring *Leo*, filled with furious fire.

The timid *Hare*, the *Dove* with *olive* green,
And *Aries*, fly in terror from the scene;
The warrior *Perseus* gazes from above,
And the *Twin* offspring of the thunderer Jove.

Lo! in the distance, *Cassiope* fair
In state reposes on her *golden chair;*
Her *beauteous daughter, bound,* before her stands,
And vainly strives to free her *fettered hands;*
For aid she calls on royal *Cepheus* near,
But shrieks from her reach not her *father's* ear.

See last of all, around the glowing pole,
With shining scales, the spiry *Dragon* roll
A grizzly *Bear* on either side appears,
Creeping with lazy motion 'mid the stars."

These lines are easily committed to memory, and would assist the pupil in recalling the names of the constellations in this very interesting portion of the heavens.

LEPUS.

THE HARE.—This constellation is situated directly south of Orion, and comes to the meridian at the same time; namely, on the 24th of January. It has a mean declination 18° S., and contains 19 small stars, of which, the four principal ones are of the 3d magnitude. It may be readily distinguished by means of four stars of the 3d magnitude, in the form of an irregular square, or trapezium.

Zeta, of the 4th magnitude, is the first star, and is situated in the back, 5° S. of Saiph, in Orion. About the same distance below Zeta are the four principal stars, in the legs and feet. These form the square. They are marked Alpha, Beta, Gamma, Delta. Alpha, otherwise called *Arneb*, and Beta form the N. W. end of the trapezium, and are about 3° apart. Gamma and Delta form the S. E. end, and are about $2\frac{1}{2}$° apart. The upper right-hand one, which is Arneb, is the brightest of the four, and is near the center of the

Where is the constellation of the Hare situated? When does it come to the meridian? What is the whole number of its stars? What is the magnitude of its principal ones? How may it be distinguished? In what part of the animal are these stars placed? Describe the principal star in Lepus. What are the distance and direction of the square from Zeta? Describe the stars at each end of this square. Which is the brightest of the four?

constellation. Four or five degrees S. of Rigel are four very minute stars, in the ears of the Hare.

HISTORY.—This constellation is situated about 18° west of the Great Dog, which, from the motion of the earth, seems to be pursuing it, as the Greyhounds do the Bear, round the circuit of the skies. It was one of those animals which Orion is said to have delighted in hunting, and which, for this reason, was made into a constellation and placed near him among the stars.

COLUMBA.

NOAH'S DOVE.—This constellation is situated about 16° S. of the Hare, and is nearly on the same meridian with the "Three Stars," in the belt of Orion. It contains only 10 stars; one of the 2d, one of the 3d, and two of the 4th magnitudes; of these, Phaet and Beta are the brightest, and are about 2½° apart. Phaet, the principal star, lies on the right and is the highest of the two; Beta may be known by means of a smaller star just east of it, marked Gamma. A line drawn from the easternmost star in the belt of Orion, 32° directly south, will point out Phaet; it is also 11½° S. of the lower left-hand star in the square of the Hare, and makes with Sirius and Naos, in the ship, a large equilateral triangle.

HISTORY.—This constellation is so called in commemoration of the dove which Noah "sent forth to see if the waters were abated from off the face of the ground," after the ark had rested on mount Ararat. "And the dove came in to him in the evening, and lo, in her mouth was an olive leaf plucked off

——————"The surer messenger,
A dove sent forth once and again to spy
Green tree or ground, whereon his foot may light:
The second time returning, in his bill
An olive leaf he brings, pacific sign!"

ERIDANUS.

THE RIVER PO.—This constellation meanders over a large and very irregular space in the heavens. It is not easy, nor scarcely desirable, to trace out all its windings among the stars. Its entire length is not less than 130°; which, for the sake of a more easy reference, astronomers divide into two sections, the northern and the southern. That part of it which lies between Orion and the Whale, including the great bend about his paws, is distinguished by the name of the *Northern stream;* the remainder of it is called the *Southern stream.*

The Northern stream commences near Rigel, in the foot of

Are these all the stars that are visible in this constellation? Describe the situation of Noah's Dove. How many stars does it contain, and what are the principal? Which of these are the brightest, and how situated? How may Beta be known? What is the position of Phaet with regard to Orion? Describe the general form of the constellation Eridanus. What is its entire length, and how is it divided? By what names are these sections distinguished? What are the course and distance of the Northern stream?

Orion, and flows out westerly, in a serpentine course nearly 40°, to the Whale, where it suddenly makes a complete circuit and returns back nearly the same distance toward its source, but bending gradually down toward the south, when it again makes a similar circuit to the S. W. and finally disappears below the horizon.

West of Rigel there are five or six stars of the 3d and 4th magnitudes, arching up in a semicircular form, and marking the *first* bend of the northern stream. About 8° below these, or 19° W. of Rigel, is a bright star of the 2d magnitude in the *second* bend of the northern stream, marked *Gamma.* This star culminates 13 minutes after the Pleiades, and one hour and a quarter before Rigel Passing Gamma, and a smaller star west of it, there are four stars nearly in a row, which bring us to the breast of Cetus. 8° N. of Gamma, is a small star named *Kied*, which is thought by some to be considerably nearer the earth than Sirius.

Theemim, in the southern stream, is a star of the 3d magnitude, about 17° S. W. of the square in Lepus, and may be known by means of a smaller star, 1° above it. *Achernar* is a brilliant star of the 1st magnitude, in the extremity of the southern stream; but having 58° of S. declination, can never be seen in this latitude.

The whole number of stars in this constellation is 84; of which, one is of the 1st magnitude, one of the 2d, and eleven are of the 3d. Many of these cannot be pointed out by verbal description; they must be traced from the map.

HISTORY.—Eridanus is the name of a celebrated river in Cisalpine Gaul, also called Padus. Its modern name is Po. Virgil calls it the king of rivers. The Latin poets have rendered it memorable from its connection with the fable of Phaeton, who, being a son of Phœbus and Clymene, became a favorite of Venus, who intrusted him with the care of one of her temples. This favor of the goddess made him vain, and he sought of his father a public and incontestable sign of his tenderness, that should convince the world of his origin. Phœbus, after some hesitation, made oath that he would grant him whatever he required, and no sooner was the oath uttered, than—

"The youth, transported, asks without delay,
To guide the sun's bright chariot for a day.
The god repented of the oath he took,
For anguish thrice his radiant head he shook;—
My son, says he, some other proof require,
Rash was my promise, rash was thy desire—
Not Jove himself, the ruler of the sky,
That hurls the three-forked thunder from above,
Dares try his strength; yet who as strong as Jove?
Besides, consider what impetuous force
Turns stars and planets in a different course.
I steer against their motions; nor am I
Borne back by all the current of the sky:
But how could you resist the orbs that roll
In adverse whirls, and stem the rapid pole?"

Phœbus represented the dangers to which he would be exposed in vain. He undertook the aerial journey, and the explicit directions of his father were forgotten. No sooner had Phaeton received the reins than he betrayed his ignorance of the manner of guiding the chariot. The flying coursers became sensible of the confusion of their driver, and immediately departed from the usual track. Phaeton repented too late of his rashness, and already heaven and earth

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Describe its first bend. Describe the position of Gamma, and tell when it comes to the meridian. *What stars are between Gamma and the Whale? What small star about 8° above Gamma, and what is its distance from the earth compared with that of Sirius? Describe the situation of Theemim. Describe the position and magnitude of Achernar?* What is the whole number of stars in this constellation? What the magnitude of the principal ones?

were threatened with a universal conflagration as the consequence, when Jupiter, perceiving the disorder of the horses, struck the driver with a thunderbolt, and hurled him headlong from heaven into the river Eridanus. His body, consumed with fire, was found by the nymphs of the place, who honored him with a decent burial, and inscribed this epitaph upon his tomb:—

"*Hic situs est Phaeton, currus auriga paterni:*
Quene si non tenuit, magnis tamen excidit ausis."

His sisters mourned his unhappy end, and were changed by Jupiter into poplars.

"All the long night their mournful watch they keep,
And all the day stand round the tomb and weep."—Ovid.

It is said the tears which they shed turned to amber, with which the Phœnicians and Carthaginians carried on in secrecy a most lucrative trade. The great heat produced on the occasion of the sun's departing out of his usual course, is said to have dried up the blood of the Ethiopians, and turned their skins black; and to have produced sterility and barrenness over the greater part of Libya.

"At once from life and from the chariot driven,
Th' ambitious boy fell thunderstruck from heaven."

* * * * * * * *

"The breathless Phaeton, with flaming hair,
Shot from the chariot like a falling star,
That in a summer's evening from the top
Of heav'n drops down, or seems at least to drop,
Till on the Po his blasted corpse was hurl'd,
Far from his country, in the western world."

The fable of Phaeton evidently alludes to some extraordinary heats which were experienced in a very remote period, and of which only this confused tradition has descended to later times.

AURIGA.

The Charioteer, called also the Wagoner, is represented on the celestial map by the figure of a man in a reclining posture, resting one foot upon the horn of Taurus, with a goat and her kids in his left hand, and a bridle in his right.

It is situated N. of Taurus and Orion, between Perseus on the W. and the Lynx on the E. Its mean declination is 45° N.; so that when on the meridian, it is almost directly overhead in New England. It is on the same meridian with Orion, and culminates at the same hour of the night. Both of these constellations are on the meridian at 9 o'clock on the 24th of January, and 1 hour and 40 minutes east of it on the 1st of January.

The whole number of visible stars in Auriga, is 66, including one of the 1st and one of the 2d magnitude, which mark the shoulders. *Capella* is the principal star in this constellation, and is one of the most brilliant in the heavens. It takes its name from Capella, the goat, which hangs upon the left shoulder. It is situated in the west shoulder of Auriga,

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How is the constellation Auriga represented? Where is it situated? What is its mean declination, and what its position on the meridian? How is it situated in respect to Orion? When are these constellations on the meridian? What is the whole number of visible stars in Auriga? How many of the 1st and 2d magnitude? What is the name of the principal star, and whence derived? Where is this situated?

24° E. of Algol, and 28° N. E. of the Pleiades. It may be known by a little sharp-pointed triangle formed by three stars, 3° or 4° this side of it, on the left. It is also 18° N. of El Nath, which is common to the northern horn of Taurus, and the right foot of Auriga. Capella comes to the meridian on the 19th of January, just 2½ minutes before Rigel, in the foot of Orion, which it very much resembles in brightness.

Menkalina, in the east shoulder, is a star of the 2d magnitude, 7¼° E. of Capella, and culminates the next minute after Betelguese, 37⅝° S. of it. *Theta*, in the right arm, is a star of the 4th magnitude, 8° directly south of Menkalina.

It may be remarked as a curious coincidence, that the two stars in the shoulders of Auriga are of the same magnitude, and just as far apart as those in Orion, and opposite to them. Again, the two stars in the shoulders of Auriga, with the two in the shoulders of Orion, mark the extremities of a long, narrow parallelogram, lying N. and S., and whose length is just five times its breadth. Also, the two stars in Auriga, and the two in Orion. make two slender and similar triangles, both meeting in a common point, half way between them at El Nath, in the northern horn of Taurus.

Delta, a star of the 4th magnitude in the head of Auriga, is about 9° N. of the two in the shoulders, with which it makes a triangle, about half the height of those just alluded to, with the vertex at Delta. The two stars in the shoulders are therefore the base of two similar triangles, one extending about 9° N., to the head, the other 18° S., to the heel, on the top of the horn: both figures together resembling an elongated diamond.

Delta in the head, Menkalina in the right shoulder, and Theta in the arm of Auriga, make a straight line with Betelguese in Orion, Delta in the square of the Hare, and Beta in Noah's Dove; all being very nearly on the same meridian. 48 W. of the solstitial colure.

"See next the Goatherd with his kids; he shines
With seventy stars, deducting only four.
Of which Capella never sets to us.*
And scarce a star with equal radiance beams
Upon the earth: two other stars are seen
Due to the second order."—*Eudosia.*

HISTORY.—The Greeks give various accounts of this constellation; some suppose it to be Erichthonius, the fourth king of Athens, and son of Vulcan and Minerva, who awarded him a place among the constellations on account of his many useful inventions. He was of a monstrous shape. He is said to have invented chariots, and to have excelled all others in the management of horses. In allusion to this, Virgil has the following lines:—

"Primus Erichthonius currus et quatuor ausus
Jungere equos, rapidisque rotis insistere victor."
Georgic. Lib. iii. p. 113.

"Bold Erichthonius was the first who join'd
Four horses for the rapid race design'd,
And o'er the dusty wheels presiding sate."—*Dryden.*

Other writers say that Bootes invented the chariot, and that Auriga was the son of Mercury, and charioteer to Œnomaus, king of Pisa, and so experienced, that he rendered his horses the swiftest in all Greece. But as neither of these fables seems to account for the goat and her kids, it has been supposed that they refer to Amalthæa and her sister Melissa, who fed Jupiter, during his infancy

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* In the latitude of London; but in the latitude of New England, Capella disappears below the horizon, in the N. N. W., for a few hours, and then reappears in the N. N. E.

How may it be known? What are its distance and direction from El Nath, in the horn of Taurus? When does Capella come to the meridian? *Describe the star in the east shoulder of Auriga. Describe Theta. What curious coincidence exists between the stars in the shoulders of Auriga and those in the shoulders of Orion? Describe the situation of Delta. The two stars in the shoulders of Auriga form the base of two triangles; please describe them. What stars in Auriga, Orion, the Hare, and the Dove, are on the same meridian? How far is this line of stars west of the solstitial colure?*

with goat's milk, and that, as a reward for their kindness, they were placed in the heavens. But there is no reason assigned for their being placed in the arms of Auriga, and the inference is unavoidable, that mythology is at fault on this point.

Jamieson is of opinion that Auriga is a mere type or scientific symbol of the beautiful fable of Phaeton, because he was the attendant of Phœbus at that remote period when Taurus opened the year.

CAMELOPARDALUS.

THE CAMELOPARD.—This constellation was made by Hevelius out of the unformed stars which lay scattered between Perseus, Auriga, the head of Ursa Major, and the Pole Star. It is situated directly N. of Auriga and the head of the Lynx, and occupies nearly all the space between these and the pole. It contains 58 small stars; the five largest of which are only of the 4th magnitude. The principal star lies in the thigh, and is about 20° from Capella, in a northerly direction. It marks the northern boundary of the temperate zone; being less than one degree S. of the Arctic circle. There are two other stars of the 4th magnitude near the right knee, 12° N. E. of the first mentioned. They may be known by their standing 1° apart and alone.

The other stars in this constellation are too small, and too much scattered to invite observation.

HISTORY.—The Camelopard is so called from an animal of that name, peculiar to Ethiopia. This animal resembles both the camel and the leopard. Its body is spotted like that of the leopard. Its neck is about seven feet long, its fore and hind legs, from the hoof to the second joint, are nearly of the same length; but from the second joint of the legs to the body, the fore legs are so long in comparison with the hind ones, that no person could sit upon its back, without instantly sliding off as from a horse that stood up on his hind feet.

CHAPTER IV.

DIRECTIONS FOR TRACING THE CONSTELLATIONS WHICH ARE ON THE MERIDIAN IN FEBRUARY.

THE LYNX.

THE constellation of the Lynx, like that of the Camelopard, exhibits no very interesting features by which it can be distinguished. It contains only a moderate number of inferior stars, scattered over a large space N. of Gemini, and between Auriga and Ursa Major. The whole number is 44, includ-

Of what was the Camelopard made? Where is it situated? What is the whole number of stars? What is the magnitude of the largest? What are the name and position of the principal one? Where are the other principal stars situated? How may they be known? *Whence does it derive its name?* What is the situation of the Lynx? What are the number and magnitude of its stars?

ing only three that are so large as the 3d magnitude. The largest of these, near the mouth, is in the solstitial colure, 14½° N. of Menkalina, in the E. shoulder of Auriga. The other two principal stars are in the brush of the tail, 3½° S. W. of another star of the same brightness in the mouth of the Lesser Lion, with which it makes a small triangle. Its center is on the meridian at 9 o'clock on the 23d, or at half-past 7 on the 1st of February.

HISTORY.—This constellation takes its name from a wild beast which is said to be of the genus of the wolf.

GEMINI.

THE TWINS.—This constellation represents, in a sitting posture, the twin brothers, Castor and Pollux.

Gemini is the *third sign*, but *fourth constellation* in the order of the Zodiac, and is situated south of the Lynx, between Cancer on the east, and Taurus on the west. The orbit of the earth passes through the center of the constellation. As the earth moves round in her orbit from the first point of Aries to the same point again, the sun, in the mean time, will *appear* to move through the *opposite* signs, or those which are situated right over against the earth, on the other side of her orbit.

Accordingly, if we could *see* the stars as the sun appeared to move by them, we should see it passing over the constellation Gemini between the 21st of June and the 23d of July; but we seldom see more than a small part of any constellation through which the sun is then passing, because the feeble luster of the stars is obscured by the superior effulgence of the sun.

When the sun is just entering the outlines of a constellation on the east, its western limit may be seen in the morning twilight, just above the rising sun. So when the sun has arrived at the western limit of a constellation, the eastern part of it may be seen lingering in the evening twilight, just behind the setting sun. Under other circumstances, when the sun is said to be in, or to enter, a particular constellation, it is to be understood that that constellation is not then visible, but that those opposite to it are. For example: whatever constellation sets with the sun on any day, it is plain that the one opposite to it must be then rising, and continue visible through the night. Also, whatever constellation rises and sets with the sun to-day, will, six months hence, rise at sun-setting, and set at sun-rising. For example: the sun is in the center of Gemini about the 6th of

Describe the position of the largest. Describe the position of the other two principal stars. What are their distance and direction from the one in the head? When is its center on the meridian? Describe the position and appearance of the Twins. What is the relative position of Gemini among the signs and constellations of the Zodiac? How is the orbit of the earth situated, with respect to these constellations? How do the sun and earth appear to move through these signs? When does the sun appear to pass through the constellation Gemini? Do we usually see the constellations while the sun is passing through them? *Under what circumstances can we see some part of them? When the sun is in or entering any constellation, are the opposite constellations visible or not? If a constellation rise with the sun to-day, how will it rise six months hence? Give an example.*

July, and must rise and set with it on that day; consequently, six months from that time, or about the 4th of January, it will rise in the east, just when the sun is setting in the west, and will come to the meridian at midnight; being then exactly opposite to the sun.

Now as the stars gain upon the sun at the rate of two hours every month, it follows that the center of this constellation will, on the 17th of February, come to the meridian three hours earlier, or at 9 o'clock in the evening.

It would be a pleasant exercise for students to propose questions to each other, somewhat like the following:—What zodiacal constellation will rise and set with the sun to-day? What one will rise at sun-setting? What constellation is three hours high at sun-set, and where will it be at 9 o'clock? What constellation rises two hours before the sun? How many days or months hence, and at what hour of the evening or morning, and in what part of the sky shall we see the constellation whose center is now where the sun is? &c., &c.

In solving these and similar questions, it may be remembered that the sun is in the vernal equinox about the 21st of March, from whence it advances through one sign or constellation every succeeding month thereafter; and that each *constellation* is one month in advance of the *sign* of that name: wherefore, reckon Pisces in March, Aries in April, Taurus in May, and Gemini in June, &c.; beginning with each constellation at the 21st, or 22d of the month.

Gemini contains 85 stars, including two of the 2d, three of the 3d, and six of the 4th magnitudes. It is readily recognized by means of the two principal stars, *Castor* and *Pollux*, of the 1st and 2d magnitudes, in the head of the Twins, about 4½° apart.

There being only 11 minutes' difference in the transit of these two stars over the meridian, they may both be considered as culminating at 9 o'clock about the 24th of February. *Castor*, in the head of Castor, is a star of the 1st magnitude, 4½° N. W. of Pollux, and is the northernmost and the brightest of the two. *Pollux*, is a star of the 2d magnitude, in the head of Pollux, and is 4½ S. E. of Castor. This is one of the stars from which the moon's distance is calculated in the Nautical Almanac.

——"Of the famed Ledean pair,
One most illustrious star adorns their sign,
And of the second order shine twin lights."

The relative magnitude or brightness of these stars has undergone considerable changes at different periods; whence it has been conjectured by various astronomers that Pollux must vary from the 1st to the 3d magnitude. But Herschel, who observed these stars for a period of 25 years, ascribes the variation to Castor, which he found to consist of two stars, very close together, the less revolving about the larger once in 342 years and two months.

Bradly and Maskelyne found that the line joining the two stars which form Castor was, at all times of the year, parallel to the line joining Castor and Pollux; and that both of the former move around a common center between them, in

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If a constellation come to the meridian at midnight to-day, how long before it will come to the meridian at 9 o'clock in the evening? If the constellation Gemini come to the meridian at midnight, on the 4th of January, when will it culminate at 9 o'clock? What is the number of stars in Gemini? By what means is it readily recognized? When do these stars culminate? Describe Castor. Describe Pollux. For what purpose is it observed at sea? Is the brightness of these two stars always the same? Who ascribes this variableness to Castor, and for what reason?

orbits nearly circular, as two balls attached to a rod would do, if suspended by a string affixed to the center of gravity between them.

"These men," says Dr. Bowditch, "were endowed with a sharpness of vision. and a power of penetrating into space, almost unexampled in the history of astronomy."

About 20° S. W. of Castor and Pollux, and in a line nearly parallel with them, is a row of stars 3° or 4° apart, chiefly of the 3d and 4th magnitudes, which distinguish the feet of the twins. The brightest of these is *Alhena*, in Pollux's upper foot; the next small star S. of it, is in his other foot: the two upper stars in the line next above Gamma, mark Castor's feet.

This row of feet is nearly two thirds of the distance from Pollux to Betelguese in Orion, and a line connecting them will pass through Alhena, the principal star in the feet. About two thirds of the distance from the two in the head to those in the feet, and nearly parallel with them, there is another row of three stars about 6° apart, which mark the knees.

There are, in this constellation, two other remarkable parallel rows, lying at right angles with the former; one, leading from the head to the foot of Castor, the brightest star being in the middle, and in the knee: the other, leading from the head to the foot of Pollux, the brightest star, called Wasat, being in the body, and Zeta, next below it, in the knee.

Wasat is in the ecliptic, and very near the center of the constellation. The two stars, Mu and Tejat, in the northern foot, are also very near the ecliptic; Tejat is a small star of between the 4th and 5th magnitudes, 2° W. of Mu, and deserves to be noticed because it marks the spot of the summer solstice, in the tropic of Cancer, just where the sun is on the longest day of the year, and is, moreover, the dividing limit between the torrid and the N. temperate zone.

Propus, also in the ecliptic, 2½° W. of Tejat, is a star of only the 5th magnitude, but rendered memorable as being the star which served for many years to determine the position of the planet Herschel, after its first discovery.

Thus as we pursue the study of the stars, we shall find continually new and more wonderful developments to engage our feelings and reward our labor. We shall have the peculiar satisfaction of reading the same volume that was spread out to the patriarchs and poets of other ages, of admiring what they admired, and of being led as they were led, to look upon these lofty mansions of being as having, above them all, a common Father with ourselves, "who ruleth in the armies of heaven, and bringeth forth their hosts by number."

HISTORY.—Castor and Pollux were twin brothers, sons of Jupiter, by Leda, the wife of Tyndarus, king of Sparta. The manner of their birth was very singular. They were educated at Pallena, and afterwards embarked with Jason in the celebrated contest for the golden fleece, at Colchis; on which occasion they behaved with unparalleled courage and bravery. Pollux distinguished himself by his achievements in arms and personal prowess, and Castor in equestrian exercises and the management of horses; whence they are represented, in the temples of Greece, on white horses, armed with spears, riding side by side, their heads crowned with a *petasus*, on whose top glittered a star. Among the ancients, and especially among the Romans, there prevailed a superstition that Castor and Pollux often appeared at the head of their armies, and led on their troops to battle and to victory.

> "Castor and Pollux, first in martial force,
> One bold on foot, and one renown'd for horse.
> Fair Leda's twins in time to stars decreed,
> One fought on foot, one curb'd the fiery steed."—*Virgil.*

> "Castor alert to tame the foaming steed,
> And Pollux strong to deal the manly deed."—*Martial.*

The brothers cleared the Hellespont and the neighboring seas from pirates after their return from Colchis; from which circumstance they have ever since been regarded as the friends and protectors of navigation. In the Argonautic expedition, during a violent storm, it is said two flames of fire were seen to play around their heads, and immediately the tempest ceased, and the sea was calm.

Describe the stars which mark the feet of the Twins. Specify the stars in each. How is this row situated with respect to Orion? Describe the second row of stars in this constellation. Are there yet other rows in this constellation? Describe them. What is the position of Wasat? Two other stars are very near the ecliptic; mention them. Describe the position of Tejat. Give a description of the star Propus.

From this circumstance, the sailors inferred, that whenever both fires appeared in the sky, it would be fair weather; but when only one appeared, there would be storms.

St. Paul, after being wrecked on the island of Melita, embarked for Rome "in a ship whose sign was *Castor* and *Pollux*;" so formed, no doubt, in accordance with the popular belief that these divinities presided over the science and safety of navigation.

They were initiated into the sacred mysteries of Cabiri, and into those of Ceres at Eleusis. They were invited to a feast at which Lynceus and Idas were going to celebrate their nuptials with Phœbe and Telaria, the daughters of Leucippus, brother to Tyndarus. They became enamored of the daughters who were about to be married, and resolved to supplant their rivals: a battle ensued, in which Castor killed Lynceus, and was himself killed by Idas. Pollux revenged the death of his brother by killing Idas; but being himself *immortal* and most tenderly attached to his deceased brother, he was unwilling to survive him; he therefore entreated Jupiter to restore him to life, or to be deprived himself of immortality: wherefore, Jupiter permitted Castor, who had been slain, to share the immortality of Pollux; and consequently as long as the one was upon earth, so long was the other detained in the infernal regions, and they alternately lived and died every day. Jupiter also further rewarded their fraternal attachment by changing them both into a constellation under the name of *Gemini*, *Twins*, which, it is strangely pretended, never appear together, but when one rises the other sets, and so on alternately.

> "By turns they visit this ethereal sky,
> And live alternate, and alternate die."—*Homer*.

> "Pollux, offering his alternate life,
> Could free his brother, and could daily go
> By turns aloft, by turns descend below."—*Virgil*.

Castor and Pollux were worshiped both by the Greeks and Romans, who sacrificed white lambs upon their altars. In the Hebrew Zodiac, the constellation of the Twins refers to the tribe of Benjamin.

CANIS MINOR.

THE LITTLE DOG.—This small constellation is situated about 5° N. of the equinoctial, and midway between Canis Major and the Twins. It contains 14 stars, of which two are very brilliant. The brightest star is called *Procyon*. It is of the 1st magnitude, and is about 4° S. E. of the next brightest, marked *Gomelza*, which is of the 3d magnitude.

These two stars resemble the two in the head of the Twins. Procyon, in the Little Dog, is 23° S. of Pollux in Gemini, and Gomelza is about the same distance S. of Castor.

A great number of geometrical figures may be formed of the principal stars in the vicinity of the Little Dog. For example; Procyon is 23° S. of Pollux, and 26° E. of Betelguese, and forms with them a large right-angled triangle. Against Procyon is equidistant from Betelguese and Sirius, and forms with them an equilateral triangle whose sides are each about 26°. If a straight line, connecting Procyon and Sirius, be produced 23° farther, it will point out Phaet, in the Dove.

Describe the situation of Canis Minor. What is its whole number of stars? What is the magnitude of its principal ones? What is the brightest one called, and how is it situated? What other stars do Procyon and Gomelza resemble? What are the distance and direction of Procyon from Pollux? Of Gomelza from Castor? What are their distance and direction from Castor and Pollux? What kind of figures may be formed of the stars in the neighborhood of the Little Dog? Give some examples.

Procyon is often taken for the name of the Little Dog, or for the whole constellation, as Sirius is for the greater one; hence it is common to refer to either of these constellations by the name of its principal star. Procyon comes to the meridian 53 minutes *after* Sirius, on the 24th of February; although it rises, in this latitude, about half an hour *before* it. For this reason, it was called *Procyon*, from two Greek words which signify (*Ante Canis*) "before the dog."

"Canicula, fourteen thy stars; but far
Above them all, illustrious through the skies.
Beams *Procyon;* justly by Greece thus called
The bright *forerunner* of the *greater Dog.*"

HISTORY.—The Little Dog, according to Greek fable, is one of Orion's hounds. Some suppose it refers to the Egyptian god Anubis, which was represented with a dog's head: others to Diana, the goddess of hunting; and others, that it is the faithful dog Mæra, which belonged to Icarus, and discovered to his daughter Erigone the place of his burial. Others, again, say it is one of Actæon's hounds that devoured their master, after Diana had transformed him into a stag, to prevent, as she said, his betraying her.

"This said, the man began to disappear
By slow degrees, and ended in a deer.
Transform'd at length, he flies away in haste,
And wonders why he flies so fast.
But as by chance, within a neighb'ring brook,
He saw his branching horns, and alter'd look,
Wretched Actæon! in a doleful tone
He tried to speak, but only gave a groan;
And as he wept, within the watery glass,
He saw the big round drops, with silent pace,
Run trickling down a savage, hairy face.
What should he do? or seek his old abodes,
Or herd among the deer, and skulk in woods?
As he thus ponders, he behind him spies
His opening hounds, and now he hears their cries.
From shouting men, and horns, and dogs he flies.
When now the fleetest of the pack that press'd
Close at his heels, and sprung before the rest,
Had fastened on him, straight another pair
Hung on his wounded side, and held him there,
Till all the pack came up, and every hound
Tore the sad huntsman groveling on the ground."*

It is most probable, however, that the Egyptians were the inventors of this constellation; and as it always rises a little before the Dog Star, which, at a particular season, they so much dreaded, it is properly represented as a little watchful creature, giving notice like a faithful sentinel of the other's approach.

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* It is not difficult to deduce the moral of this fable. The selfishness and caprice of human friendship furnish daily illustrations of it. While the good man, the philanthropist, or the public benefactor, is in affluent circumstances, and, with a heart to devise, has the power to minister blessings to his numerous beneficiaries, his virtues are the general theme: but when adverse storms have changed the ability, though they could not shake the will of their benefactor, he is straightway pursued, like Actæon, by his own hounds; and, like Actæon, he is "torn to the ground" by the fangs that fed upon his bounty.—L. Q. C. L.

What name is usually given to the Little Dog? When does Procyon rise and culminate, with respect to the Dog Star? What name, for this reason, was given to this constellation?

MONOCEROS.

The Unicorn.—This is a modern constellation, which was made out of the unformed stars of the ancients that lay scattered over a large space of the heavens between the two Dogs. It extends a considerable distance on each side of the equinoctial, and its center is on the same meridian with Procyon.

It contains 31 small stars, of which the seven principal ones are of only the 4th magnitude. Three of these are situated in the head, 3° or 4° apart, forming a straight line N. E. and S. W. about 9° E. of Betelguese in Orion's shoulder, and about the same distance S. of Alhena in the foot of the Twins.

The remaining stars in this constellation are scattered over a large space, and being very small, are unworthy of particular notice.

History.—The Monoceros is a species of the Unicorn or Rhinoceros. It is about the size of a horse, with one white horn growing out of the middle of its forehead. It is said to exist in the wilds of Ethiopia, and to be very formidable.

Naturalists say that, when pursued by the hunters, it precipitates itself from the tops of the highest rocks, and pitches upon its horn, which sustains the whole force of its fall, so that it receives no damage thereby. Sparmann informs us, that the figure of the unicorn, described by some of the ancients, has been found delineated on the surface of a rock in Caffraria; and thence conjectures that such an animal, instead of being *fabulous*, as some suppose, did once actually exist in Africa. Lobo affirms that he has seen it.

The *rhinoceros*, which is akin to it, is found in Bengal, Siam, Cochin China, part of China Proper, and the isles of Java and Sumatra.

CANIS MAJOR.

The Great Dog.—This interesting constellation is situated southward and eastward of Orion, and is universally known by the brilliance of its principal star, *Sirius*, which is apparently the largest and brightest in the heavens. It glows in the winter hemisphere with a luster which is unequaled by any other star in the firmament.

Its distance from the earth, though computed at 20 millions of millions of miles, is supposed to be less than that of any other star: a distance, however, so great that a cannon ball, which flies at the rate of 19 miles a minute, would be two millions of years in passing over the mighty interval; while sound, moving at the rate of 13 miles a minute, would reach Sirius in little less than three millions of years.

What stars compose the constellation Monoceros? How is this constellation situated, and when is it on the meridian? What is the whole number of its stars? What is the magnitude of its principal ones? Describe those in the head. Describe the position and appearance of Canis Major. What is its appearance in the winter? What is its distance from the earth computed to be, and how is it compared with that of the other stars? How long would it take a cannon-ball to pass over this distance. In what time would sound reach Sirius from the earth

It may be shown in the same manner, that a ray of light, which occupies only 8 minutes and 13 seconds in coming to us from the sun, which is at the rate of nearly two hundred thousand miles a second, would be 3 years and 82 days in passing through the vast space that lies between Sirius and the earth. Consequently, were it blotted from the heavens, its light would continue visible to us for a period of 3 years and 82 days after it had ceased to be.

If the *nearest* stars give such astonishing results, what shall we say of those which are situated a thousand times as far *beyond* these, as these are from us?

In the remote ages of the world, when every man was his own astronomer, the rising and setting of Sirius, or the *Dog Star*, as it is called, was watched with deep and various solicitude. The ancient Thebans, who first cultivated astronomy in Egypt, determined the length of the year by the number of its risings. The Egyptians watched its rising with mingled apprehensions of hope and fear; as it was ominous to them of agricultural prosperity or blighting drought. It foretold to them the rising of the Nile, which they called *Siris*, and admonished them when to sow. The Romans were accustomed yearly to sacrifice a dog to Sirius, to render him propitious in his influence upon their herds and fields. The eastern nations generally believed the rising of Sirius would be productive of great heat on the earth.

Thus Virgil:—

———"Tum steriles exurere Sirius agros:
Ardebant herbæ, et victum seges ægra negabat."

———"Parched was the grass, and blighted was the corn:
Nor 'scape the beasts; for Sirius, from on high,
With pestilential heat infects the sky."

Accordingly, to that season of the year when Sirius rose with the sun and seemed to blend its own influence with the heat of that luminary, the ancients gave the name of *Dog-days*, (*Dies Caniculares.*) At that remote period the Dog-days commenced on the 4th of August, or four days after the summer solstice, and lasted forty days or until the 14th of September. At present the Dog-days begin on the 3d of July, and continue to the 11th of August, being one day less than the ancients reckoned.

Hence, it is plain that the Dog-days of the moderns have no reference whatever to the rising of Sirius, or any other star, because the *time* of their rising is perpetually accelerated by the precession of the equinoxes: they have reference then only to the summer solstice which never changes its position in respect to the seasons.

How long is light in coming from Sirius to the earth? Suppose this star were now be blotted from the heavens, how long before its twinkling would expire? How was the rising of Sirius regarded in the remote ages of the world? What use was made of it by the ancient Thebans? How did the Egyptians regard it, and for what reason? What did it foretell to them? What did the Romans offer in sacrifice to Sirius annually? Why? How was it regarded by the eastern nations generally? What season of the year did the ancients call *Dog-days?* When did these begin, and how long did they last? At present, when do they begin and end? Have our Dog-days any reference to the Dog Star?

The time of Sirius' rising varies with the latitude of the place, and in the same latitude, is sensibly changed after a course of years, on account of the precession at the equinoxes. This enables us to determine with approximate accuracy, the dates of many events of antiquity, which cannot be well determined by other records. We do not know, for instance, in what precise period of the world Hesiod flourished. Yet he tells us in his *Opera et Dies*, lib. ii. v. 185, that Arcturus in his time rose heliacally, 60 days after the winter solstice, which then was in the 9th degree of Aquarius, or 39° beyond its present position. Now 39° : 50¼″ = 2794 years since the time of Hesiod, which corresponds very nearly with history.

When a star rose at sun-setting, or set at sun-rising, it was called the *Achronical* rising or setting. When a planet or star appeared above the horizon just before the sun, in the morning, it was called the *Heliacal* rising of the star; and when it sunk below the horizon immediately after the sun, in the evening, it was called the *Heliacal* setting. According to Ptolemy, stars of the *first* magnitude are seen rising and setting when the sun is 12° below the horizon; stars of the 2d magnitude require the sun's depression to be 13°; stars of the 3d magnitude, 14°, and so on, allowing one degree for each magnitude. The rising and setting of the stars described in this way, since this mode of description often occurs in Hesiod, Virgil, Columella, Ovid, Pliny, &c., are called *poetical* rising and setting. They served to mark the times of religious ceremonies, the seasons allotted to the several departments of husbandry, and the overflowing of the Nile.

The student may be perplexed to understand how the Dog Star, which he seldom sees till mid-winter, should be associated with the most fervid heat of summer. This is explained by considering that this star, in summer, is over our heads in the *daytime*, and in the lower hemisphere at night. As "thick the floor of heaven is inlaid with patines of bright gold," by day, as by night; but on account of the superior splendor of the sun, we cannot see them.

Sirius is situated nearly S. of Alhena, in the feet of the Twins, and about as far S. of the equinoctial as Alhena is N. of it. It is about 10° E. of the Hare, and 26° S. of Betelguese in Orion, with which it forms a large equilateral triangle. It also forms a similar triangle with Phaet in the Dove, and Naos in the Ship. These two triangles being joined at their vertex in Sirius, present the figure of an enormous X, called by some, the EGYPTIAN X. Sirius is also pointed out by the direction of the Three Stars in the belt of Orion. Its distance from them is about 23°. It comes to the meridian at 9 o'clock on the 11th of February.

Mirzam, in the foot of the Dog, is a star of the 2d magnitude, 5½° W. of Sirius. A little above, and 4° or 5° to the left, there are three stars of the 3d and 4th magnitudes, forming a triangular figure somewhat resembling a dog's head.

What is meant by the Achronical rising and setting of the stars? What, by their Heliacal rising and setting? By whom were the terms thus applied, and what were these risings and settings called? What did they serve? Explain how it is, that the Dog Star, which is seldom seen till mid-winter, should be associated with the most fervid heat of summer. Are there as many stars over our head in the daytime as in the night? Describe the situation of Sirius. What is its position with regard to Betelguese and Procyon, and in connection with them what figure does it form? With what other stars does it form a similar triangle? What is the appearance of these two triangles taken together? How else is Sirius pointed out? Describe the position and magnitude of Mirzam. What stars mark the head of the Dog?

The brightest of them, on the left, is called *Muliphen.* It entirely disappeared in 1670, and was not seen again for more than 20 years. Since that time it has maintained a steady luster.

Wesen is a star of between the 2d and 3d magnitudes, in the back, 11° S. S. E. of Sirius, with which, and Mirzam in the paw, it makes an elongated triangle. The two hinder feet are marked by Naos and Lambda, stars of the 3d and 4th magnitudes, situated about 3° apart, and 12° directly S. of the forefoot. This constellation contains 31 visible stars, including one of the 1st magnitude, four of the 2d, and two of the 3d; all of which are easily traced out by the aid of the map.

HISTORY.—Manilius, a Latin poet who flourished in the Augustan age, wrote an admirable poem, in five books, upon the fixed stars, in which he thus speaks of this constellation:—

"All others he excels; no fairer light
Ascends the skies, none sets so clear and bright."

But EUDOSIA best describes it:—

"Next shines the *Dog* with sixty-four distinct;
Famed for pre-eminence in envied song,
Theme of *Homeric* and Virgilian lays:
His fierce mouth flames with dreaded *Sirius;*
Three of his stars retire with feeble beams."

According to some mythologists, this constellation represents one of Orion's hounds, which was placed in the sky, near this celebrated huntsman. Others say it received its name in honor of the dog given by Aurora to Cephalus, which surpassed in speed all the animals of his species. Cephalus, it is said, attempted to prove this by running him against a fox, which, at that time, was thought to be the fleetest of all animals. After they had run together a long time without either of them obtaining the victory, it is said that Jupiter was so much gratified at the fleetness of the dog, that he assigned him a place in the heavens.

But the name and form of this constellation are, no doubt, derived from the Egyptians, who carefully watched its rising, and by it judged of the swelling of the Nile, which they called Siris, and, in their hieroglyphical manner of writing, since it was as it were the sentinel and watch of the year, represented it under the figure of a dog. They observed that when Sirius became visible in the east, just before the morning dawn, the overflowing of the Nile immediately followed. Thus it warned them, like a faithful dog, to escape from the region of the inundation.

CHAPTER V.

DIRECTIONS FOR TRACING THE CONSTELLATIONS WHICH ARE ON THE MERIDIAN IN MARCH.

ARGO NAVIS.

THE SHIP ARGO.—This constellation occupies a large space in the southern hemisphere, though but a small part

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Which is the brightest of these, and what remarkable circumstance in its history? How has it appeared since its return? Describe the situation and magnitude of Wesen? What stars mark the hinder feet? What is the number of visible stars in this constellation? Describe the constellation Argo Navis?

of it can be seen in the United States. It is situated S. E. of Canis Major, and may be known by the stars in the prow and deck of the ship.

If a straight line joining Betelguese and Sirius, be produced 18° to the southeast, it will point out *Naos*, a star of the 2d magnitude, in the rowlock of the ship. This star is in the S. E. corner of the Egyptian X, and of the large equilateral triangle made by itself with Sirius and the Dove. When on the meridian, it is seen from this latitude about 8° above the southern horizon. It comes to the meridian on the 3d of March, about half an hour after Procyon, and continues visible but a few hours.

Gamma, in the middle of the ship, is a star of the 2d magnitude, about 7° S. of Naos, and just skims above the southern horizon for a few minutes, and then sinks beneath it. The principal star in this constellation is called, after one of the pilots, *Canopus;* it is of the 1st magnitude, 36° nearly S. of Sirius, and comes to the meridian 17 minutes after it; but having about 53° of S. declination, it cannot be seen in the United States. The same is true of *Miaplacidus*, a star of the 1st magnitude in the oars of the ship, about 25° E. of Canopus, and 61° S. of Alphard, in the heart of Hydra.

An observer in the northern hemisphere, can see the stars as many degrees south of the equinoctial in the southern hemisphere, as his own latitude lacks of 90°, and no more.

Markeb, is a star of the 4th magnitude, in the prow of the ship, and may be seen from this latitude, 16° S. E. of Sirius, and about 10° E. of Wesen, in the back of the Dog. This star may be known by its forming a small triangle with two others of the same magnitude, situated a little above it, on the E., 3° and 4° apart.

This constellation contains 64 stars, of which two are of the 1st magnitude, four of the 2d, and nine of the 3d. Most of these are too low down to be seen in the United States.

HISTORY.—This constellation is intended to perpetuate the memory of the famous ship which carried Jason and his 54 companions to Colchis, when they resolved upon the perilous expedition of recovering the golden fleece. The derivation of the word *Argo* has been often disputed. Some derive it from Argos, supposing that this was the name of the person who first proposed the expedition, and built the ship. Others maintain that it was built at Argos, whence its name. Cicero calls it Argo, because it carried Grecians, commonly called Argives. Diodorus derives the word from ἀργός, which signifies *swift*. Ptolemy says, but not truly, that Hercules built the ship and called it Argo, after a son of Jason, who bore the same name. This ship had fifty oars, and being thus propelled must have fallen far short of the bulk of the smallest *ship* craft used by moderns.

Where is it situated? Point out the situation of Naos, in the ship? When may it be seen in this latitude? When is it on the meridian? Describe the position and magnitude of Gamma. What are the situation and name of the principal star in this constellation? Why can it not be seen in the United States? Is any other considerable star in the ship similarly situated? Describe Markeb. How may this star be known? What is the number of visible stars in this constellation? What is the magnitude of its principal ones?

It is even said that the crew were able to carry it on their backs from the Danube to the Adriatic.

According to many authors, she had a beam on her prow. cut in the forest of Dodona by Minerva, which had the power of giving oracles to the Argonauts. This ship was the first, it is said, that ever ventured on the sea. After the expedition was finished, and Jason had returned in triumph, he ordered her to be drawn ashore at the isthmus of Corinth, and consecrated to Neptune, the god of the sea.

Sir Isaac Newton endeavors to settle the period of this expedition at about 30 years before the destruction of Troy, and 43 years after the death of Solomon. Dr. Bryant, however, rejects the history of the Argonautic expedition as a mere fiction of the Greeks, and supposes that this group of stars, which the poets denominate Argo Navis, refers to Noah's ark and the deluge, and that the fable of the Argonautic expedition is founded on certain Egyptian traditions that related to the preservation of Noah and his family during the flood.

CANCER

THE CRAB is now the fifth constellation and fourth sign of the Zodiac. It is situated in the ecliptic, between Leo on the E. and Gemini on the W. It contains 83 stars, of which one is of the 3d, and seven of the 4th magnitude. Some place the first-mentioned star in the same class with the other seven, and consider none larger than the 4th magnitude.

Beta is a star of the 3d or 4th magnitude, in the south-western claw, 10° N. E. of Procyon, and may be known from the fact that it stands alone, or at least has no star of the same magnitude near it. It is midway between Procyon and Acubens.

Acubens, is a star of similar brightness, in the south-eastern claw, 10° N. E. of Beta, and nearly in a straight line with it and Procyon. An imaginary line drawn from Capella through Pollux, will point out Acubens, at the distance of 24° from Pollux. It may be otherwise distinguished by its standing between two very small stars close by it in the same claw.

Tegmine, the last in the back, appears to be a small star, of between the 5th and 6th magnitudes, 8½° in a northerly direction from Beta. It is a treble star, and to be distinctly seen, requires very favorable circumstances. Two of them are so near together that it requires a telescopic power of 300 to separate them.

About 7° north-easterly from Tegmine, is a nebulous cluster of very minute stars, in the crest of Cancer, sufficiently luminous to be seen by the naked eye. It is situated in a triangular position with regard to the head of the Twins and the Little Dog. It is about 20° W. of each. It may otherwise be discovered by means of two conspicuous stars of

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What is the relative position of Cancer among the signs and constellations of the Zodiac? How is it situated? What are the number and magnitude of its stars? Where is Beta situated, and how may it be known? Which way from Procyon and Acubens? Describe Acubens. What are its distance and direction from Pollux? How may it be otherwise known? Describe Tegmine. There is a remarkable cluster in this constellation—describe its position. How may it otherwise be discovered?

the 4th magnitude lying one on either side of it, at the distance of about 2°, called the *northern* and *southern Aselli.* By some of the Orientalists, this cluster was denominated *Præsepe*, the *Manger*, a contrivance which their fancy fitted up for the accommodation of the *Aselli* or *Asses;* and it is so called by modern astronomers. The appearance of this nebula to the unassisted eye, is not unlike the nucleus of a comet, and it was repeatedly mistaken for the comet of 1832, which, in the month of November, passed in its neighborhood.

The southern Asellus, marked Delta, is situated in the line of the ecliptic, and, in connection with Wasat and Tejat, marks the course of the earth's orbit for a space of 36° from the solstitial colure.

There are several other double and nebulous stars in this constellation, most of which are too small to be seen; and indeed, the whole constellation is less remarkable for the brilliancy of its stars than any other in the Zodiac.

The sun arrives at the *sign* Cancer about the 21st of June, but does not reach the *constellation* until the 23d of July.

The mean right ascension of Cancer is 126°. It is consequently on the meridian the 3d of March.

A few degrees S. of Cancer, and about 17° E. of Procyon, are four stars of the 4th magnitude, 3° or 4° apart, which mark the head of Hydra. This constellation will be described on Map III.

The beginning of the *sign* Cancer (not the constellation) is called the *Tropic of Cancer*, and when the sun arrives at this point, it has reached its utmost limit of north declination, where it seems to remain stationary a few days before it begins to decline again to the south. This stationary attitude of the sun is called the summer *solstice;* from two Latin words signifying the *sun's standing still.* The distance from the first point of Cancer to the equinoctial, which, at present, is 23° 27⅔', is called the *obliquity of the ecliptic.* It is a remarkable and well-ascertained fact, that this is continually growing less and less. The tropics are slowly and steadily approaching the equinoctial, at the rate of about half a second every year; so that the sun does not now come so far north of the equator in summer, nor decline so far south in winter, as it must have done at the creation, by nearly a degree.

HISTORY.—In the Zodiacs of Esne and Dendera, and in most of the astrological remains of Egypt, a Scarabæus, or Beetle, is used as the symbol of this sign; but in Sir William Jones' Oriental Zodiac, and in some others found in India, we meet with the figure of a crab. As the Hindoos, in all probability, derived their knowledge of the stars from the Chaldeans, it is supposed that the figure of the crab, in this place, is more ancient than the Beetle.

In some eastern representations of this sign, two animals, like asses, are found in this division of the Zodiac; and as the Chaldaic name for the ass may be translated *muddiness*, it is supposed to allude to the discoloring of the Nile, which river was rising when the sun entered Cancer. The Greeks, in copying this sign, have placed two asses as the appropriate symbol of it, which still re-

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What is the name of this cluster? What is its appearance to the naked eye, and for what has it been mistaken? How is the star called the southern Asellus situated, with respect to the ecliptic? What other stars in this *constellation*? At what time does the sun enter the *sign* Cancer? At what time the *constellation*? *Where is the tropic of Cancer situated? When the sun reaches this point, what is said of its declination? What is this stationary attitude of the sun called? What is the obliquity of the ecliptic? What remarkable fact in respect to this distance? Does this affect the stability of the tropics?*

main. They explain their reason, however, for adopting this figure, by saying that these are the animals that assisted Jupiter in his victory over the giants.

Dopuis accounts for the origin of the asses in the following words:—Le Cancer, où sont les étoiles appellées les anes, forme l'impreinte du pavillon d' Issachar que Jacob assimile a l'ane.

Mythologists give different accounts of the origin of this constellation. The prevailing opinion is, that while Hercules was engaged in his famous contest with the dreadful Lernæan monster, Juno, envious of the fame of his achievements, sent a sea-crab to bite and annoy the hero's feet, but the crab being soon dispatched, the goddess to reward its services, placed it among the constellations.

"The Scorpion's claws here clasp a wide extent,
And here the Crab's in lesser clasps are bent."

CHAPTER VI.

DIRECTIONS FOR TRACING THE CONSTELLATIONS WHICH ARE ON THE MERIDIAN IN APRIL.

LEO.

The Lion.—This is one of the most brilliant constellations in the winter hemisphere, and contains an unusual number of very bright stars. It is situated next E. of Cancer, and directly S. of Leo Minor and the Great Bear.

The Hindoo astronomer, Varaha. says, "Certainly the southern solstice was once in the middle of *Asleha* (*Leo*); the northern in the first degree of *Dhanishta*" (*Aquarius*). Since that time, the solstitial, as well as the equinoctial points, have gone backward on the ecliptic 75°. This divided by 50¼″, gives 5373 years; which carry us back to the year of the world 464. Sir W. Jones says, that Varaha lived when the solstices were in the first degrees of Cancer and Capricorn; or about 400 years before the Christian era.

Leo is the *fifth sign*, and the *sixth* constellation of the Zodiac. The mean right ascension of this extensive group is 150°, or 10 hours. Its center is therefore on the meridian the sixth of April. Its western outline, however, comes to the meridian on the 18th of March, while its eastern limit does not reach it before the 3d of May.

This constellation contains 95 visible stars, of which one is of the 1st magnitude, one of the 2d, six of the 3d, and fifteen of the 4th.

'One splendid star of highest dignity,
One of the second class the Lion boasts,
And justly figures the fierce summer's rage."

The principal star in this constellation is of the 1st magnitude, situated in the breast of the animal, and named *Regulus*, from the illustrious Roman consul of that name.

What is the general appearance of the constellation Leo? Where is it situated? What is the relative order among the signs and constellations of the Zodiac? What is the right ascension of Leo, and when is its center on the meridian? When do the outlines of the figure come to the meridian? What number of visible stars does it contain, and how large are the principal ones? What is the name of the first star in the constellation, and whence is it derived?

It is situated almost exactly in the ecliptic, and may be readily distinguished on account of its superior brilliancy. It is the largest and lowest of a group of five or six bright stars which form a figure somewhat resembling a sickle, in the neck and shoulder of the Lion. There is a little star of the 5th magnitude about 2° S. of it, and one of the 3d magnitude 5° N. of it, which will serve to point it out.

Regulus is the brightest star in the constellation. Great use is made of it, by nautical men, for determining their longitude at sea. Its *latitude*, or distance from the *ecliptic*, is less than ½°; but its *declination*, or distance from the *equinoctial*, is nearly 13° N.; so that its meridian altitude will be just equal to that of the sun on the 19th of August. Its right ascension is very nearly 150°. It therefore culminates about 9 o'clock on the 6th of April.

When Regulus is on the meridian, Castor and Pollux are seen about 40° N. W. of it, and the two stars in the Little Dog are about the same distance in a S. W. direction; with which, and the two former, it makes a large isosceles triangle whose vertex is at Regulus.

The next considerable star is 5° N. of Regulus, marked *Eta*, situated in the collar; it is of between the 3d and 4th magnitudes, and with Regulus constitutes the handle of the sickle. Those three or four stars of the 3d magnitude, N. and W. of Eta, arching round with the neck of the animal, describe the blade.

Al Gieba is a bright star of the 2d magnitude, situated in the shoulder, 4° in a N. E. direction from Eta, and may be easily distinguished by its being the brightest and middle one of the three stars lying in a semicircular form curving toward the west; and it is the first in the blade of the sickle.

Adhafera is a star of the 3d magnitude, situated in the neck, 4° N. of *Al Gieba*, and may be known by a very minute star just below it. This is the second star in the blade of the sickle.

Ras al Asad, situated before the ear, is a star of the 3d or 4th magnitude, 6° W. of Adhafera, and is the third in the blade of the sickle. The next star, *Epsilon*, of the same magnitude, situated in the head, is 2½° S. W. of Ras al Asad, and a little *within* the curve of the sickle. About midway

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Describe the situation of Regulus. What other stars serve to point it out? What is its comparative brightness? What use is made of it in nautical astronomy? What are its latitude and declination? On what day will Regulus culminate at 9 o'clock in the evening? *When is it on the meridian, with what stars does it form a large triangle, and in what direction are they from it?* What are the name and position of the next considerable star in its vicinity? What stars form the blade of the sickle? Where is Al Gieba situated, and how may it be distinguished? What is the position of Adhafera, and how muy it be known? Describe the situation of Ras al Asad.

between these, and a little to the E., is a very small star hardly visible to the naked eye.

Lambda, situated in the mouth, is a star of the 4th magnitude, 3½° S.W. of Epsilon, and the last in the sickle's point. *Kappa*, situated in the nose, is another star of the same magnitude, and about as far from Lambda as Epsilon. Epsilon and Kappa are about 5½° apart, and form the longest side of a triangle, whose vertex is in Kappa.

Zozma, situated in the back of the Lion, is a star of the 3d magnitude, 18° N. E. of Regulus, and midway between it and Coma Berenices, a fine cluster of small stars, 18° N. E. of Zozma.

Theta, situated in the thigh, is another star of the 3d magnitude, 5° directly S. of Zozma, and so nearly on the same meridian that it culminates but one minute after it. This star makes a right-angled triangle with Zozma on the N. and Denebola on the E., the right angle being at Theta.

Nearly in a straight line with Zozma and Theta, and south of them, are three or four smaller stars, 4° or 5° apart, which mark one of the legs.

Denebola is a bright star of the first magnitude, in the brush of the tail, 10° S. E. of Zozma, and may be distinguished by its great brilliancy. It is 5° W. of the equinoctial colure, and comes to the meridian 1 hour and 41 minutes after Regulus, on the 3d of May ; when its meridian altitude is the same as the sun's at 12 o'clock the next day.

When Denebola is on the meridian, Regulus is seen 25° W. of it, and Phad, in the square of Ursa Major, bears 39° N. of it. It forms, with these two, a large right-angled triangle ; the right angle being at Denebola. It is so nearly on the same meridian with Phad that it culminates only four minutes before it.

Denebola is 35½° W. of Arcturus, and about the same distance N. W. of Spica Virginis, and forms, with them, a large equilateral triangle on the S. E. It also forms with Arcturus and Cor Caroli a similar figure, nearly as large on the N. E. These two triangles, being joined at their base, constitute a perfect geometrical figure of the forms of a Rhombus, called by some, the DIAMOND OF VIRGO.

A line drawn from Denebola through Regulus, and continued 7° or 8° further in the same direction, will point out *Xi* and *Omicron*, of the 3d and 4th magnitudes, situated in the foreclaws, and about 3° apart.

What star is next? Describe the position of Lambda. What are the situation and magnitude of Kappa? What is the distance between Epsilon and Kappa? Describe the position of Zozma. What are the magnitude and position of Theta? What geometrical figure may be formed with this star, Zozma and Denebola? What stars in this neighborhood mark one of the legs of Leo? Describe Denebola. How far is it from the equinoctial colure, and when does it come to the meridian? *When Denebola is on the meridian, what geometrical figure does it form, in connection with Regulus and Phad? With what other star is it nearly on the same meridian?* What is the position of Denebola in regard to Arcturus and Spica Virginis, and what figure does it form with them? With what other stars does Denebola form a similar figure? What large geometrical figure is formed by these two triangles? *What stars point out those in the foreclaws?*

There are a number of other stars of the 3d and 4th magnitudes in this constellation, which require no description, as the scholar will easily trace them out from the map. The position of Regulus and Denebola are often referred to in the geography of the heavens, as they serve to point out other clusters in the same neighborhood.

History.—According to Greek fable, this Lion represents the formidable animal which infested the forests of Nemæa. It was slain by Hercules, and placed by Jupiter among the stars in commemoration of the dreadful conflict. Some writers have applied the story of the twelve labors of Hercules to the progress of the sun through the twelve signs of the ecliptic; and as the combat of that celebrated hero with the Lion was his first labor, they have placed Leo as the *first sign*. The figure of the Lion was, however, on the Egyptian charts long before the invention of the fables of Hercules. It would seem, moreover, according to the fable itself, that Hercules, who represented the sun, actually slew the Nemæan Lion, because *Leo* was already a zodiacal sign.

In hieroglyphical writing the Lion was an emblem of violence and fury; and the representation of this animal in the Zodiac, signified the intense heat occasioned by the sun when it entered that part of the ecliptic. The Egyptians were much annoyed by lions during the heat of summer, as they at that season left the desert, and haunted the banks of the Nile, which had then reached its greatest elevation. It was therefore natural for their astronomers to place the Lion where we find him in the Zodiac.

The figure of Leo, very much as we now have it, is in all the Indian and Egyptian Zodiacs. The overflowing of the Nile, which was regularly and anxiously expected every year by the Egyptians, took place when the sun was in this sign. They therefore paid more attention to it, it is to be presumed, than to any other. This was the principal reason, Mr. Green supposes, why Leo stands first in the zodiacs of Dendera.

The circular zodiac, mentioned in our accounts of Aries, and which adorned the ceiling in one of the inner rooms in the famous temple in that city, was brought away *en masse* in 1821, and removed to Paris. On its arrival at the Louvre, it was purchased by the king for 150,000 francs, and, after being exhibited there for a year, was placed in one of the halls of the library, where it is now to be seen in apparently perfect preservation. This most interesting relic of astrology, after being cut away from the ruins where it was found, is about one foot thick, and eight feet square. The rock of which it is composed, is sandstone. On the face of this stone appears a large square, inclosing a circle four feet in diameter, in which are arranged, in an irregular spiral line, the zodiacal constellations, commencing with the sign Leo. On each side of this spiral line are placed a great variety of figures. These are supposed to represent other constellations, though they bear no analogy, in form, to those which we now have. Many of these figures are accompanied with hieroglyphics, which probably express their names. The commentator of Champollion, from whom we have derived many interesting facts in relation to them, has furnished merely a *general* history of their origin and purpose, but does not add particulars. Copies of these drawings and character have been exhibited in this country, and the wonderful conclusions that have been drawn from them have excited much astonishment.

Compared with our present planispheres, or with stellar phenomena, it abounds with contradictory and irrelevant matter. So far from proving what was strenuously maintained by infidel writers, soon after its discovery, that the Greeks took from it the model of their zodiac, which they have transmitted to us, it seems to demonstrate directly the reverse. The twelve signs, it is true, are there, but they are not in their proper places. Cancer is between Leo and the pole; Virgo bears no proportion to the rest; some of the signs are placed double; they are all out of the ecliptic, and by no means occupy those regular and equal portions of space which Egyptian astronomers are said to have exactly measured by means of their *clepsydra*.

The figures, without what may be termed the zodiacal circle, could never have included the same stars in the heavens which are now circumscribed by the figures of the constellations. Professor Green is of opinion, that the small apartment in the ruins of Dendera, which was mysteriously ceiled with this zodiac, was used for the purposes of judicial astrology, and that the sculptured figures upon it were employed in horoscopical predictions, and in that casting of nativities for which the Egyptians were so famous.

Why is the position of Regulus and Denebola often referred to?

In the Hebrew Zodiac, Leo is assigned to Judah, on whose standard, according to all traditions, a Lion is painted. This is clearly intimated in numerous passages of the Hebrew writings: Ex.—"Judah is a Lion's whelp; he stooped down, he couched as a Lion, and as an old Lion; who shall rouse him up?" Gen. xlix. 9. "The Lion of the tribe of Judah hath prevailed." Rev. v. 5.

LEO MINOR.

The Little Lion.—This constellation was formed by Hevelius, out of the *Stellæ informes*, or unformed stars of the ancients, which lay scattered between the Zodiacal constellation Leo on the S., and Ursa Major on the N. Its mean right ascension is the same with that of Regulus, and it comes to the meridian at the same time on the 6th of April.

The modern constellations, or those which have been added to our celestial maps since the adoption of the Greek notation, in 1603, are referred to by the letters of the English alphabet, instead of the Greek. This is the case in regard to Leo Minor, and all other constellations whose origin is subsequent to that period.

Leo Minor contains 53 stars, including only one of the 3d magnitude, and 5 of the 4th. The principal star is situated in the body of the animal, 13° N. of Gamma Leonis,* in a straight line with Phad, and may be known by a group of smaller stars, a little above it on the N. W.

It forms an equilateral triangle with Gamma and Delta Leonis, the vertex being in Leo Minor. This star is marked with the letter *l*, in modern catalogues, and being the principal representative of the constellation, is itself sometimes called the Little Lion: 8° E. of this star (the Little Lion) are two stars of the 4th magnitude, in the last paw of Ursa Major and about 10° N. W. of it, are two other stars of the 3d magnitude, in the first hind paw.

"The *Smaller Lion* now succeeds; a cohort
Of fifty stars attend his steps;
And *three*, to sight unarm'd, invisible."

SEXTANS.

The Sextant, called also Urania's Sextant,† is a modern constellation that Hevelius made out of the unformed stars of the ancients, which lay scattered between the Lion on the N., and Hydra on the S.

It contains 41 very small stars, including only one as large

* *Leonis* is the genitive or possessive case of Leo, and *Gamma Leonis* means the Gamma of Leo. Thus also the principal star in Aries is marked *Alpha Arietis*, meaning the Alpha of Aries, &c.

† Urania was one of the muses, and daughter of Jupiter and Mnemosyne. She presided over astronomy. She was represented as a young virgin, dressed in an azure-colored robe, crowned with stars, holding a robe in her hands, and having many mathematical instruments about her.

What is the origin of Leo Minor, and how is it situated? What is its mean right ascension? When is it on the meridian? What are the number and magnitude of its stars? What is the position of the principal star in this constellation, and how may it be known? *What figure does it form with some other stars? What letter represents this star, and what else is it called? What nebulæ do we find in this constellation?* What are the origin and position of the Sextant? How many stars does it contain?

as the 4th magnitude. This is situated very near the equinoctial, 13° S. of Regulus, and comes to the meridian about the same time on the 6th of April. The other stars in this constellation are too small to engage attention. A few of the largest of them may be traced out from the map.

HISTORY.—A sextant, in mathematics, is the sixth part of a circle, or an arch comprehending 60 degrees. But the term is more particularly used to denote an astronomical instrument well known to mariners. Its use is the same as that of the quadrant; namely, to measure the angular distance, and take the altitude of the sun, moon, planets, and fixed stars. It is indispensable to the mariner in finding the latitude and longitude at sea, and should be in the hands of every surveyor and practical engineer. It may serve the purpose of a theodolite, in measuring inaccessible heights and distances. It may gratify the young pupil to know, that by means of such an instrument, well adjusted, and with a clear eye and a steady hand, he could readily tell, within a few hundred yards, how far north or south of the equator he was, and that from any quarter of the world, known or unknown. This constellation is so called, on account of a supposed resemblance to this instrument.

HYDRA AND THE CUP.

HYDRA, THE WATER SERPENT, is an extensive constellation, winding from E. to W. in a serpentine direction, over a space of more than 100 degrees in length. It lies south of Cancer, Leo and Virgo, and reaches almost from Canis Minor to Libra. It contains sixty stars, including one of the 2d magnitude, three of the 3d, and twelve of the 4th.

Alphard, or *Cor Hydræ*, in the heart, is a lone star of the 2d magnitude, 23° S. S. W. of Regulus, and comes to the meridian at the same time with Lambda, in the point of the sickle, about 20 minutes before 9 o'clock on the 1st of April. There is no other considerable star near it, for which it can be mistaken. An imaginary line drawn from Gamma Leonis through Regulus, will point out Cor Hydræ, at the distance of 23°.

The head of Hydra may be distinguished by means of four stars of the 4th magnitude, 2½° and 4° apart, situated 6° S. of Acubens, and forming a rhomboidal figure. The three upper stars in this cluster form a small arch, and may be known by two very small stars just below the middle one, making with it a very small triangle. The three western stars in the head also make a beautiful little triangle. The eastern star in this group, marked *Zeta*, is about 6° directly S. of Acubens, and culminates at the same time.

When Alphard is on the meridian, *Alkes*, of the 4th magnitude, situated in the bottom of the Cup, may be seen 24°

What is the position of the largest one? Describe the situation and extent of the constellation Hydra. What are the number and magnitude of its stars? Describe the position and magnitude of Alphard. What are the distance and direction of Cor Hydræ from Gamma Leonis? How may the head of Hydra be distinguished? How may the three upper stars in this cluster be known? Which stars form a beautiful little triangle? How is Alkes situated, and when may it be seen?

S. E. of it, and is distinguished by its forming an equilateral triangle with Beta and Gamma, stars of the same magnitude, 6° S. and E. of it. Alkes is common both to Hydra and the Cup. Beta, on the S., is in Hydra, and Gamma, on the N. E., is near the middle of the Cup. A line drawn from Zozma, through Theta Leonis, and continued 38½° directly S. will reach Beta ; it is therefore on the same meridian, and will culminate at the same time on the 23d of April.

The Cup itself, called also the *Crater*, may be easily distinguished by means of six stars of the 4th magnitude, forming a beautiful crescent, or semicircle, opening to the W. The center of this group is about 15° below the equinoctial, and directly S. of the hinder feet of Leo. The crescent form of the stars in the Cup is so striking and well defined, when the moon is absent, that no other description is necessary to point them out. Its center comes to the meridian about two hours after Alphard, on the same evening ; and consequently, it culminates at 9 o'clock, one month after Alphard does. The remainder of the stars in this constellation may be easily traced by aid of the map.

When the head of Hydra is on the meridian, its other extremity is many degrees below the horizon, so that its whole length cannot be traced out in the heavens until its center, or the Cup, is on the meridian.

——" Near the equator rolls
The sparkling Hydra, proudly eminent
To drink the *Galaxy's* refulgent sea ;
Nearly a fourth of the encircling curve
Which girds the ecliptic, his vast folds involve ;
Yet *ten* the number of his stars diffused
O'er the long track of his enormous spires :
Chief beams his heart, sure of the second rank,
But emulous to gain the first."—*Eudosia.*

HISTORY.—The astrologers of the east, in dividing the celestial hosts into various compartments, assigned a popular and allegorical meaning to each. Thus the sign *Leo*, which passes the meridian about midnight, when the sun is in Pisces, was called *the House of the Lions*, Leo being the domicil of Sol.

The introduction of two serpents into the constellations of the ancients, had its origin, it is supposed, in the circumstances that the polar one represented the oblique course of the stars, while the Hydra, or Great Snake, in the southern hemisphere, symbolized the moon's course ; hence the *Nodes* are called *the Dragon's head and tail to this day.*

The hydra was a terrible monster, which, according to mythologists, infested the neighborhood of the lake Lerna, in the Peloponnesus. It had a hundred heads, according to Diodorus ; fifty, according to Simonides ; and nine, according to the more commonly received opinion of Apollodorus, Hyginus, and others. As soon as one of these heads was cut off, two immediately grew up if the wound was not stopped by fire.

If Alkes be situated in the *Cup*, why is it also included in Hydra ? How are the other two stars that make a triangle with Alkes situated ? How is Beta situated with respect to Zozma and Theta Leonis ? When is Beta on the meridian ? How may the Cup be distinguished ? How is the center of this group situated with respect to Leo and the equinoctial ? What single circumstance is sufficient to designate the stars in the Cup ? When is it on the meridian ? When the head of Hydra is on the meridian where is the other extremity of the constellation ?

"Art thou proportion'd to the hydra's length,
Who by his wounds received augmented strength?
He raised a hundred hissing heads in air,
When one I lopp'd, up sprang a dreadful pair."

To destroy this dreadful monster, was one of the labors of Hercules, and this he easily effected with the assistance of Iolaus, who applied a burning iron to the wounds as soon as one head was cut off. While Hercules was destroying the hydra, Juno, jealous of his glory, sent a sea-crab to bite his foot. This new enemy was soon dispatched; and Juno was unable to succeed in her attempts to lessen the fame of Hercules. The conqueror dipped his arrows in the gall of the hydra, which ever after rendered the wounds inflicted with them incurable and mortal.

This fable of the many-headed hydra may be understood to mean nothing more than that the marshes of Lerna were infested with a multitude of serpents, which seemed to multiply as fast as they were destroyed.

CHAPTER VII.

DIRECTIONS FOR TRACING THE CONSTELLATIONS WHICH ARE ON THE MERIDIAN IN MAY.

URSA MAJOR.

The Great Bear.—This great constellation is situated between Ursa Minor on the north, and Leo Minor on the south. It is one of the most noted and conspicuous in the northern hemisphere. It has been an object of universal observation in all ages of the world. The priests of Belus and the Magi of Persiathe shepherds, of Chaldea, and the Phœnician navigators, seem to have been equally struck with its peculiar outlines. And it is somewhat remarkable, that a remote nation of American Aborigines, the Iroquois, and the earliest Arabs of Asia, should have given to the very same constellation the name of "Great Bear," when there had probably never been any communication between them; and when the name itself is so perfectly arbitrary, there being no resemblance whatever to a bear, or to any other animal.

It is readily distinguished from all others by means of a remarkable cluster of seven bright stars, forming what is familiarly termed the *Dipper*, or *Ladle*. In some parts of England it is called "Charles' Wain," or wagon, from its fancied resemblance to a wagon drawn by three horses in a line. Others call it the Plough. The cluster, however, is more frequently put for the whole constellation, and called simply the Great Bear. But we see no reason to reject the very ap-

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How is Ursa Major situated? How has it always been regarded? What people seem to have been peculiarly struck with its splendor? What remarkable circumstance respecting its name? Is there any resemblance between the outlines of this constellation and the figure of a bear? By what is this constellation readily distinguished from all others? By what other names is the Dipper called? What is this cluster more frequently called?

propriate appellation of the shepherds, for the resemblance is certainly in favor of the Dipper; the four stars in the square forming the bowl, and the other three the handle.

When the Dipper is on the meridian, above the pole, the bottom lies toward us, with the handle on the right.

Benetnasch is a bright star of the 2d magnitude, and is the first in the handle. The second, or middle star in the handle is *Mizar*, 7° distant from Benetnasch. It may be known by means of a very minute star almost touching it, called *Alcor*, which appears to be double when seen through a telescope, and of a silver white. The third star in the handle is called *Alioth*, and is about 4½° W. of Mizar. Alioth is very nearly opposite Shedir in Cassiopeia, and at an equal distance from the pole. Benetnasch, Mizar, and Alioth constitute the handle, while the next four in the square form the bowl of the Dipper.

Five and a half degrees W. of Alioth is the first star in the *top* of the Dipper, at the junction of the handle, called *Megrez;* it is the smallest and middle one of the cluster, and is used in various observations both on sea and land for important purposes.* At the distance of 4½° S. W. of Megrez is Phad, the first star in that part of the bottom which is next the handle.

The stars in this cluster are so well known, and may be so easily described without reference to their relative bearings, that they would rather confuse than assist the student, were they given with ever so much accuracy. The several bearings for this cluster were taken when Megrez was on the meridian, and will not apply at any other time, though their respective distances will remain the same.

At the distance of 8° W. of Phad, is the westernmost star in the bottom of the Dipper, called *Merak*. The bright star 5° N. of it, toward the pole, is called *Dubhe;* but these two, Merak and Dubhe, are, by common consent, called the *Pointers*, because they always point toward the pole; for, let the line which joins them be continued in the same direction 28¾° farther, it will just reach the north pole.

The names, positions, and relative distances of the stars in this cluster should be well remembered, as they will be fre-

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* When Megrez and Caph have the same altitude, and are seen in the same horizontal line east and west, the polar star is then at its greatest elongation from the true pole of the heavens; and this is the proper time for an observer to take its angle of elevation, in order to determine the *latitude*, and its azimuth or angle of declination, in order to determine the magnetic variation.

What, on the whole, is an appropriate appellation for it, and why? Describe the position of the Dipper when on the meridian. Describe the position of Benetnasch. What is the next star in the Dipper, and how may it be known? What is the next, or third star in the Dipper? What stars form the bowl and handle of the Dipper? Describe the position and use of Megrez. What star is situated next to Megrez? Describe the position of Merak and Dubhe. What are these stars called, and why?

quently adverted to. The distance of Dubhe, or the Pointer nearest to the north pole, is 28¾°. The distance between the two upper stars in the Dipper is 10°; between the two lower ones is 8°; the distance from the brim to the bottom next the handle, is 4½°; between Megrez and Alioth, is 5½°; between Alioth and Mizar, 4½°; and between Mizar and Benetnasch, 7°.

The reason why it is important to have these distances clearly settled in the mind is, that these stars, being always in view, and more familiar than any other, the student will never fail to have a standard measure before him, which the eye can easily make use of in determining the distances between other stars.

The position of Megrez in Ursa Major, and of Caph in Cassiopeia, is somewhat remarkable. They are both in the equinoctial colure, almost exactly opposite each other, and equally distant from the pole. Caph is in the colure, which passes through the vernal equinox, and Megrez is in that which passes through the autumnal equinox. The latter passes the meridian at 9 o'clock, on the 10th of May, and the former just six months afterward, at the same hour, on the 10th of November.

Psi, in the left leg of Ursa Major, is a star of the 4th magnitude, in a line with Megrez and Phad, distant from the latter 12½°. A little out of the same line, 3° farther, is another star of the 4th magnitude, marked *Epsilon*, which may be distinguished from Psi, from its forming a straight line with the two *Pointers*.

The right forepaw, and the two hinder ones, each about 15° from the other, are severally distinguished by two stars of the 4th magnitude, between 1° and 2° apart. These three duplicate stars are nearly in a right line, 20° S. of, and in a direction nearly parallel with Phad and Dubhe, and are the only stars in this constellation that ever set in this latitude.

There are a few other stars of equal brightness with those just described, but amidst the more splendid and interesting group with which they are clustered, they seldom engage our observation.

The whole number of visible stars in this constellation is 87; of which five are of the 2d, two of the 3d, and about twice as many of the 4th magnitude.

HISTORY.—URSA MAJOR is said to be Calisto, or Helice, daughter of Lycaon,

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What is the distance of Dubhe from the north pole? Mention the relative distances between the other stars in this group. *Why is it important to have the relative distances of these stars from each other well settled in the mind?* What is there remarkable in the position of Megrez, and Caph in Cassiopeia? When do they pass the meridian? Describe the position of Psi. Where is Epsilon situated, and how may it be distinguished? How are the paws of the Bear distinguished? What is the situation of these stars with respect to Phad and Dubhe? What are the only stars in this constellation that ever set in this latitude? What is the whole number of visible stars in this constellation, and how many of each magnitude?

king of Arcadia. She was an attendant of Diana,* and mother of Arcas, by Jupiter, who placed her among the constellations, after the jealousy of Juno had changed her into a bear.

"This said, her hand within her hair she wound.
Swung her to earth, and dragg'd her on the ground;
The prostrate wretch lifts up her hand in prayer;
Her arms grow shaggy, and deform'd with hair,
Her nails are sharpen'd into pointed claws,
Her hands bear half her weight, and turn to paws;
Her lips, that once could tempt a god, begin
To grow distorted in an ugly grin;
And lest the supplicating brute might reach
The ears of Jove, she was deprived of speech.

* * * * * *

How did she fear to lodge in woods alone,
And haunt the fields and meadows, once her own!
How often would the deep-mouth'd dogs pursue,
Whilst from her hounds the frighted hunters flew."—*Ovid's Met.*

Some suppose that her son Arcas, otherwise called Bootes, was changed into Ursa Minor, or the Little Bear. It is well known, that the ancients represented both these constellations under the figure of a wagon drawn by a team of horses; hence the appellation of *Charles' Wain*, or wagon. This is alluded to in the Phenomena of Aratus, a Greek poem, from which St. Paul quotes in his address to the Athenians:—

"The one call'd Helix,† soon as day retires,
Observed with ease lights up his radiant fires:

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* Diana was the goddess of hunting, and the patroness of modesty and chastity;—

"The huntress *Dian*,
Fair, silver-shafted queen, forever chaste,
——————set at naught
The frivolous bolt of Cupid; gods and men
Fear her stern frown, and she was queen o' th' woods."—*Milton.*

The most famous of her temples was that of Ephesus, near Smyrna, in Asia, which was one of the seven wonders of the world. It is related in the Acts of the Apostles, that "Demetrius, a silversmith, who made silver shrines for Diana," endeavored to excite opposition to the Christian religion, because "this Paul had persuaded much people that they be no gods which are made with hands," and "that the temple of the great goddess Diana should be despised, and *her* magnificence should be destroyed, whom all Asia and the world worshipeth. And when they heard these sayings they were full of wrath, and cried out, saying, *Great is Diana of the Ephesians!* And thus they continued shouting for the space of two hours." And again, "When the town clerk had appeased the people, he said, Ye men of Ephesus, what man is there that knoweth not how that the city of the Ephesians is a *worshiper* of the great goddess Diana, and of the image which fell down from Jupiter?"

The "image which fell down from Jupiter," doubtless alludes to the fable that Juno cast her out of heaven, and that Neptune, in pity of her desolate condition, raised the island of Delos, from the Ægean sea, for her birth and habitation; for it was in this island that the twins, Apollo and Diana, were born. Diana is therefore sometimes called *Delia*, from the name of the island that gave her birth. She was represented under the figure of a very beautiful virgin, in a hunting dress, a head taller than any of her attendant nymphs, with a bow in her hand, a quiver suspended across her shoulders, and her forehead ornamented with a silver crescent "which Jews might kiss and infidels adore." The inhabitants of Taurica sacrificed upon her altars all the strangers that were shipwrecked upon their coast. The Lacedemonians yearly offered her human victims till the age of Lycurgus, who changed this barbarous custom of immolation to flagellation. The Athenians generally offered her goats, while others offered white kids and ewes.

"Haste the sacrifice;
Seven bullocks yet unyoked for Phœbus choose.
And for Diana, seven unspotted ewes."—*Virgil.*

Who does not bow with grateful veneration at that Christian intrepidity of St. Paul, who risked his life in exposing the delusion and idolatry of the worshipers of the goddess Diana?

It is a remarkable circumstance, that the temple of Diana was burnt to the ground the very day on which Alexander the great was born!

† Calisto was a native of the city of Helice, in Achaia, a district near the bay of Corinth; hence the Greater Bear is sometimes called Helice:—

"Night on the earth pour'd darkness; on the sea,
The watchful sailor, to Orion's star
And *Helice*, turn'd heedful."—*Apollonius.*

The other, smaller, and with feebler beams,
In a less circle drives its lazy teams;
But more adapted for the sailor's guide,
Whene'er, by night, he tempts the briny tide."

In the Egyptian planispheres of remote antiquity, these two constellations are represented by the figures of bears, instead of wagons; and the Greeks, who derived most of their astronomical symbols from the Egyptians, though they usually altered them to emblems of their own history or superstition, have nevertheless, retained the original form of the two bears. It is said by Aratus, that the Phenician navigators made use of Ursa Minor in directing their voyages:—

"Observing this, Phenicians plough the main:"

while the Greeks confined their observations to Ursa Major.

Some imagine that the ancient Egyptians arranged the stars near the north pole within the outlines of a bear, because the polar regions are the haunts of this animal, and also because it makes neither extensive journeys nor rapid marches.

At what period men began to sail by the stars, or who were the first people that did so, is not clear; but the honor is usually given to the Phenicians. That it was practiced by the Greeks, as early as the time of the Trojan war, that is, about 1200 years B. C., we learn from Homer; for he says of Ulysses, when sailing on his raft, that

"Placed at the helm he sate, and mark'd the skies,
Nor closed in sleep his ever watchful eyes."

It is rational to suppose that the stars were first used as a guide to travelers by land, for we can scarcely imagine that men would venture themselves upon the sea by night, before they had first learned some safe and sure method of directing their course by land. And we find, according to Diodorus Siculus, that travelers in the sandy plains of Arabia were accustomed to direct their course by *the Bears.*

That people traveled in these vast deserts at night by observing the stars, is directly proved by this passage of the Koran:—"God has given you the stars to be guides in the dark, both by land and by sea."

COMA BERENICES.

Berenice's Hair.—This is a beautiful cluster of small stars, situated about 5° E. of the equinoctial colure, and midway between Cor Caroli on the north-east, and Denebola on the south-west. If a straight line be drawn from Benetnasch through Cor Caroli, and produced to Denebola, it will pass through it.

The principal stars are of between the 4th and 5th magnitudes. According to Flamsted, there are thirteen of the 4th magnitude, and according to others there are seven; but the student will find agreeably to his map, that there is apparently but *one* star in this group, entitled to that rank, and this is situated about 7° S. E. of the main cluster.

Although it is not easy to mistake this group for any other in the same region of the skies, yet the stars which compose it are all so small as to be rarely distinguished in the full presence of the moon. The confused luster of this assem-

Describe the appearance and situation of Coma Berenices. What are the magnitudes of the principal stars in this cluster? What are they, according to Flamsted and others? How many stars of the 4th magnitude will the student find on the map? Is it easy to mistake this group, and is it visible in presence of the moon?

blage of small stars somewhat resembles that of the Milky-Way. It contains, besides the stars already alluded to, a number of nebulæ.

The whole number of stars in this constellation is 43; its mean right ascension is 185°. It consequently is on the meridian the 13th of May.

——————"Now behold
The glittering maze of *Berenice's Hair;*
Forty the stars; but such as seem to kiss
The *flowing tresses* with a lambent fire,
Four to the telescope alone are seen."

History.—Berenice was of royal descent, and a lady of great beauty, who married Ptolemy Soter, or Evergetes, one of the kings of Egypt, her own brother, whom she loved with much tenderness. When he was going on a dangerous expedition against the Assyrians, she vowed to dedicate her hair to the goddess of beauty, if he returned in safety. Some time after the victorious return of her husband, Evergetes, the locks, which, agreeably to her oath, she had deposited in the temple of Venus, disappeared. The king expressed great regret at the loss of what he so much prized; whereupon Conon, his astronomer, publicly reported that Jupiter had taken away the queen's locks from the temple, and placed them among the stars.

"There *Berenice's locks* first rose so bright,
The heavens bespangling with disheveled light."

Conon, being sent for by the king, pointed out this constellation, saying, "There behold the locks of the queen." This group being among the unformed stars until that time, and not known as a constellation, the king was satisfied with the declaration of the astronomer, and the queen became reconciled to the partiality of the gods.

Callimachus, a historian and poet, who flourished long before the Christian era, has these lines as translated by Tytler:—

"Immortal Conon, blest with skill divine,
Amid the sacred skies behold me shine:
E'en me, the *beauteous hair*, that lately shed
Refulgent beams from *Berenice's* head;
The *lock* she fondly vowed with lifted arms,
Imploring all the powers to save from harms
Her dearer lord, when from his bride he flew,
To wreak stern vengeance on the Assyrian crew."

CORVUS.

The Crow.—This small constellation is situated on the eastern part of Hydra, 15° E. of the Cup, and is on the same meridian with Coma Berenices, but as far S. of the equinoctial as Coma Berenices is N. of it. It therefore culminates at the same time, on the 12th of May. It contains nine visible stars, including three of the 3d magnitude and two of the 4th.

This constellation is readily distinguished by means of three stars of the 3d magnitude and one of the 4th, forming a trapezium or irregular square, the two upper ones being about 3½° apart, and the two lower ones 6° apart.

What does its luster resemble? What is the number of stars in this constellation, and when is it on the meridian? Where is the Crow situated? When is it on the meridian? What are the number and magnitude of its stars? How is it readily distinguished?

The brightest of the two upper stars, on the left, is called *Algorab*, and is situated in the E. wing of the Crow; it has nearly the same declination S. that the Dog Star has, and is on the meridian about the 13th of May. It is 21½° E. of Alkes in the Cup, 14½° S. W. of Spica Virginis, a brilliant star of the 1st magnitude to be described in the next chapter.

Beta, on the back of Hydra and in the foot of the Crow, is a star of the 3d magnitude, nearly 7° S. of Algorab. It is the brightest of the two lower stars, and on the left. The right-hand lower one is a star of the 4th magnitude, situated in the neck, marked *Epsilon*, about 6° W. of Beta, and may be known by a star of the same magnitude situated 2° below it, in the eye, and called *Al Chiba*. Epsilon is 21⅗° S. of the vernal equinox, and if a meridian should be drawn from the pole through Megrez, and produced to Epsilon Corvi, it would mark the equinoctial colure.

Gamma, in the W. wing, is a star of the 3d magnitude, 3½° W. of Algorab, and is the upper right-hand one in the square. It is but 1° E. of the equinoctial colure.

10° E. of Beta is a star of the 3d magnitude, in the tail of Hydra, marked *Gamma;* these two, with Algorab, form nearly a right-angled triangle, the right angle being at Beta.

HISTORY.—The Crow, it is said, was once of the purest white, but was changed for tale-bearing to its present color. A fit punishment for such a fault'

"The raven once in snowy plumes was drest,
White as the whitest dove's unsullied breast,
Fair as the guardian of the capitol,
Soft as the Swan; a large and lovely fowl;
His tongue, his prating tongue, had changed him quite,
To sooty blackness from the purest white."

According to Greek fable, the Crow was made a constellation by Apollo. This god being jealous of Coronis, (whom he tenderly loved,) the daughter of Phlegyas and mother of Æsculapius, sent a crow to watch her behavior; the bird perceived her criminal partiality for Ischys the Thessalian, and immediately acquainted Apollo with her conduct, which so fired his indignation that he lodged an arrow in her breast, and killed her instantly.

"The god was wroth; the color left his look,
The wreath his head, the harp his hand forsook;
The silver bow and feathered shafts he took,
And lodged an arrow in the tender breast,
That had so often to his own been prest."

To reward the crow, he placed her among the constelrations.

Others say that this constellation takes its name from the daughter of Coronæus, king of Phocis, who was transformed into a crow by Minerva, to rescue the maid from the pursuit of Neptune. The following, from an eminent Latin poet of the Augustan age, is her own account of the metamorphosis as translated into English verse by Mr. Addison:—

"For as my arms I lifted to the skies,
I saw black feathers from my fingers rise:

Describe the position of Algorab. How does its declination compare with that of Sirius? What are its distance and direction from Alkes and Spica Virginis? Describe the situation of Beta. Describe the situation of the right-hand lower star. What is the distance of Epsilon from the vernal equinox, and how may the equinoctial colure be traced out by it? What are the magnitude and position of Gamma? Of Beta?

I strove to fling my garment on the ground;
My garment turned to plumes, and girt me round:
My hands to beat my naked bosom try;
Nor naked bosom now nor hands had I:
Lightly I tripp'd, nor weary as before
Sunk in the sand, but skimm'd along the shore;
Till, rising on my wings, I was preferr'd
To be the chaste Minerva's virgin bird."

VIRGO.

The Virgin.—This is the sixth sign, and seventh constellation in the ecliptic. It is situated next east of Leo, and about midway between Coma Berenices on the N. and Corvus on the S. It occupies a considerable space in the heavens, and contains, according to Flamsted, one hundred and ten stars, including one of the 1st, six of the 3d, and ten of the 4th magnitudes. Its mean declination is 5° N., and its mean right ascension is 195°. Its center is therefore on the meridian about the 23d of May.

The sun enters the *sign* Virgo, on the 23d of August, but does not enter the *constellation* before the 15th of September. When the sun is in this sign, the earth is in Pisces; and *vice versa.*

Spica Virginis, in the ear of corn* which the virgin holds in her left hand, is the most brilliant star in this constellation, and situated nearly 15° E. N. E. of Algorab in the Crow, about 35° S. E. of Denebola, and nearly as far S. S. W. of Arcturus—three very brilliant stars of similar magnitude that form a large equilateral triangle, pointing to the S. Arcturus and Denebola are also the base of a similar triangle on the north, terminating in Cor Caroli, which, joined to the former, constitutes the *Diamond of Virgo.* The length of this figure, from Cor Caroli on the north to Spica Virginis on the south, is 50°. Its breadth, or shorter diameter, extending from Arcturus on the east to Denebola on the west, is 35½°. Spica may otherwise be known by its solitary splendor, there being no visible star near it except one of the 4th magnitude, situated about 1° below it, on the left.

The position of this star in the heavens, has been determined with great exactness for the benefit of navigators. It

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* In the Egyptian Zodiac, *Isis*, whose place was supplied by Virgo, was represented with three ears of corn in her hand. According to the Egyptian mythology, Isis was said to have dropped a sheaf of corn, as she fled from Typhon, who, as he continued to pursue her, scattered it over the heavens. The Chinese call the Zodiac the *yellow road*, as resembling a path over which the ripened ears of corn are scattered.

What is the relative position of Virgo among the signs and constellations of the ecliptic? How is it situated? How many stars does it contain, and how large are the principal ones? What are its mean declination and right ascension? When is the center of the constellation on the meridian? Describe the principal star in Virgo. What are the distance and direction of Virgo from Algorab, Denebola and Arcturus? What are the magnitude and appearance of these three stars, and what figure do they form? How may Spica be otherwise distinguished? Why has its position been determined with great exactness?

is one of the stars from which the moon's distance is taken for determining the longitude at sea. Its situation is highly favorable for this purpose, as it lies within the moon's path, and little more than 2° below the earth's orbit.

Its right ascension being 199°, it will come to our meridian at 9 o'clock about the 28th of May, in that point of the heavens where the sun is at noon about the 20th of October.

Vindemiatrix, is a star of the 3d magnitude, in the right arm, or northern wing of Virgo, and is situated nearly in a straight line with, and midway between Coma Berenices and Spica Virginis. It is 19½° S. W. of Arcturus, and about the same distance S. E. of Coma Berenices, and forms with these two a large triangle. pointing to the south. It bears also 18° S. S. E. of Denebola, and comes to the meridian about 23 minutes before Spica Virginis.

Zeta, is a star of the 3d magnitude 11½° N. of Spica, and very near the equinoctial. *Gamma*, situated near the left side, is also a star of the 3d magnitude, and very near the equinoctial. It is 13° due west of Zeta, with which and Spica it forms a handsome triangle. *Eta*, is a star of the 3d magnitude, in the southern wing, 5° W. of Gamma, and but 2½° E. of the autumnal equinox.

Beta, called also *Zavijava*, is a star of the 3d magnitude, in the shoulder of the wing. 7½° W. of Eta, with which and Gamma it forms a line near the Earth's orbit, and parallel to it. Beta, Eta, Gamma and Spica, form the lower aud longer side of a large spherical triangle whose vertex is in Beta. The other stars in this figure may be easily traced by means of the map. About 13° E. of Spica, there are two stars of the 4th magnitude, 3° apart, which mark the foot of Virgo. These two stars are on nearly the same meridian with Arcturus, and culminate nearly at the same time. The lower one, marked *Lambda*, is on the south, and but 8° W. of the principal star in Libra. Several other stars of the 3d magnitude lie scattered about in this constellation, and may be traced out by the map.

> "Her lovely tresses glow with starry light;
> Stars ornament the bracelet on her hand;
> Her vest in ample fold, glitters with stars:
> Beneath her snowy feet they shine; her eyes
> Lighten, all glorious, with the heavenly rays,
> But *first* the star which crowns the golden sheaf."

HISTORY.—The famous zodiac of Dendera, as we have already noticed, commences with the sign Leo; but another zodiac, discovered among the ruins at Esne, in Egypt, commences with Virgo: and from this circumstance, some have argued, that the regular precession of the equinoxes established a date to this at least 2000 years older than that at Dendera. The discoveries of Champollion, however, render it probable that this ancient relic of astrology at Esne was erected during the reign of the Emperor Claudius, and consequently did not precede the one at Dendera more than fourteen years.

Of this, however, we may be certain: the autumnal equinox now corresponds with the first degree of *Virgo*; and, consequently, if we find a zodiac in which the summer solstice was placed where the autumnal equinox now is, that zodiac carries us back 90° on the ecliptic; this divided by the annual precession 50¼″, must fix the date at about 6450 years ago. This computation, according to the chronology of the Sacred writings, carries us back to the earliest ages of the human species on earth, and proves, at least, that astronomy was among the first studies of mankind. The most rational way of accounting for this zodiac, says Jamieson, is to ascribe it to the family of Noah; or perhaps to the patriarch himself, who constructed it for the benefit of those who should live after the deluge, and who preserved it as a monument to perpetuate the actual state of the heavens immediately subsequent to the creation.

Fable represents the ancient Egyptians as believing that the yearly and regular inundations of the Nile proceeded from the abundant tears which Isis shed

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Why is its situation favorable for taking the moon's distance? When does it pass our meridian? *Describe the situation of Vindemiatrix. Describe the figure which it forms with other stars in the same neighborhood. What are its distance and bearing from Denebola? Describe Zeta. Describe Gamma. Describe the position of Eta. Describe the position of Beta. What geometrical figure may be formed of the stars in this neighborhood?*

for the loss of Osiris, whom Typhon had basely murdered. By confounding the simple allegory of the learned with the mythological creed of the vulgar, the historical account furnished us respecting Isis. becomes perplexed and unintelligible. Perhaps with the following key we may unlock the mystery:—The sun in Leo, was adored as the god Osiris; in Virgo, it was worshiped as his sister Isis; at its passage into Scorpio, the terrible reign of Typhon commenced. Columella fixes the transit of the sun into Scorpio, on the 13th of the calends of November; and this period nearly corresponds with that in which Osiris was feigned to have been slain by Typhon, and the death of Orion was to have been occasioned by the sting of a scorpion. When Scorpio begins to rise, Orion sets; when Scorpio comes to the meridian, Leo begins to set:—Typhon then reigns, Osiris is slain, and his sister follows him to the tomb weeping. The traditions allot the sign Virgo to Naphthali, whose standard had for its symbol a tree "bearing goodly branches."

Thus mythology, in describing the physical state of the world, invented a symbolical language which personified inanimate objects; and the priests reduced the whole of their noblest science to fables, which the people believed as true histories representing the *moral* condition of mankind during the first ages of civil government.

According to the ancient *poets*, this constellation represents the Virgin Astræa, the goddess of justice, who lived upon the earth during the golden age; but being offended at the wickedness and impiety of mankind during the brazen and iron ages of the world, she returned to heaven, and was placed among the constellations of the zodiac, with a pair of scales (Libra) in one hand and a sword in the other.

Hesiod, who flourished nearly a thousand years before the birth of our Saviour, and later writers, mention four ages of the world; the golden, the silver, the brazen, and the iron age. In the beginning of things, say they, all men were happy, and all men were good; the earth brought forth her fruits without the labor of man; and cares, and wants, wars and diseases, were unknown. But this happy state of things did not last long. To the golden age, the silver age succeeded; to the silver, the brazen; and to the brazen, the iron. Perpetual spring no longer reigned; men continually quarreled with each other; crime succeeded to crime; and blasphemy and murder stained the history of every day. In the golden age, the gods did not disdain to mix familiarly with the sons of men. The innocence, the integrity and brotherly love which they found among us, were a pleasing spectacle even to superior natures; but as mankind degenerated, one god after another deserted their late beloved haunts; Astræa lingered the last; but finding the earth steeped in human gore, she herself flew away to the celestial regions.

"Victa jacet pietas; et virgo cæde madentes
Ultima cœlestum terras Astræa reliquit."
Met. Lib. i. v. 149.

"Faith flees, and piety in exile mourns;
And *justice* here oppress'd, to heaven returns."

Some, however, maintain, that Erigone was changed into the constellation Virgo. The death of her father Icarus, an Athenian, who perished by the hands of some peasants, whom he had intoxicated with wine, caused a fit of despair, in which Erigone hung herself; and she was afterward, as it is said, placed among the signs of the zodiac. She was directed by her faithful dog Mæra to the place where her father was slain. The first bough on which she hung herself breaking, she sought a stronger, in order to effect her purpose.

"Thus once in Marathon's impervious wood,
Erigone beside her father stood,
When hastening to discharge her pious vows,
She loos'd the knot, and cull'd the strongest boughs."
LEWIS' Statius, B. xi.

ASTERION ET CHARA; VEL CANES VENATICI.

THE GREYHOUNDS.—This modern constellation, embracing two in one, was made by Hevelius out of the unformed stars

What is the origin of the constellation called the Greyhounds?

of the ancients which were scattered between Bootes on the east, and Ursa Major on the west, and between the handle of the Dipper on the north, and Coma Berenices on the south.

These Hounds are represented on the celestial sphere as being in pursuit of the Great Bear, which Bootes is hunting round the pole of heaven, while he holds in his hand the leash by which they are fastened together. The northern one is called *Asterion*, and the southern one, *Chara*.

The stars in this group are considerably scattered, and are principally of the 5th and 6th magnitudes; of the twenty-five stars which it contains, there is but one sufficiently large to engage our attention. *Cor Caroli*, or *Charles' Heart*, so named by Sir Charles Scarborough, in memory of King Charles the First, is a star of the 3d magnitude, in the neck of Chara the Southern Hound.

When on the meridian, Cor Caroli is 17½° directly S. of Alioth, the third star in the handle of the Dipper, and is so nearly on the same meridian that it culminates only one minute and a half after it. This occurs on the 20th of May.

A line drawn from Cor Caroli through Alioth will lead to the N. polar star. This star may also be readily distinguished by its being in a straight line with, and midway between Benetnasch, the first star in the handle of the Dipper, and Coma Berenices; and also by the fact that when Cor Caroli is on the meridian, Denebola bears 23° S. W., and Arcturus 26° S. E. of it, forming with these two stars a very large triangle, whose vertex is at the north; it is also at the northern extremity of the large Diamond already described.

The remaining stars in this constellation are too small and too much scattered to excite our interest.

CHAPTER VIII.

DIRECTIONS FOR TRACING THE CONSTELLATIONS WHICH ARE ON THE MERIDIAN IN JUNE.

BOOTES.*

THE BEAR-DRIVER is represented by the figure of a huntsman in a running posture, grasping a club in his right hand, and holding up in his left the leash of his two greyhounds, Asterion and Chara, with which he seems to be pursuing the Great Bear round the pole of the heavens. He is thence called Arctophylax, or the "Bear-Driver."

* Pronounced Bo-o'-tes.

How are the Greyhounds represented? By what names are they distinguished? What are the magnitudes of the stars which compose this group, and how are they situated with respect to each other? Describe the principal star. *When on the meridian what is its situation with regard to Alioth? How is Cor Caroli situated with respect to the polar star? How may this star be otherwise readily distinguished? What large geometrical figure does it form with two other bright stars in its vicinity?* How is the constellation Bootes represented? Why is Bootes called the Bear Driver?

This constellation is situated between Corona Borealis on the east, and Cor Caroli, or the Greyhounds, on the west. It contains fifty-four stars, including one of the 1st magnitude, seven of the 3d, and ten of the 4th. Its mean declination is 20° N., and its mean right ascension is 212°; its center is therefore on the meridian the 9th of June.

Bootes may be easily distinguished by the position and splendor of its principal star, *Arcturus*, which shines with a reddish luster, very much resembling that of the planet Mars.

Arcturus is a star of the 1st magnitude, situated near the left knee, 26° S. E. of Cor Caroli and Coma Berenices, with which it forms an elongated triangle, whose vertex is at Arcturus. It is 35½° E. of Denebola, and nearly as far N. of Spica Virginis, and forms with these two, as has already been observed, a large equilateral triangle. It also makes, with Cor Caroli and Denebola, a large triangle whose vertex is in Cor Caroli.

A great variety of geometrical figures may be formed of the stars in this bright region of the skies. For example; Cor Caroli on the N., and Spica Virginis on the S., constitute the extreme points of a very large figure in the shape of a diamond; while Denebola on the W. and Arcturus on the E., limit the mean diameter at the other points.

Arcturus is supposed by some to be nearer the earth than any other star in the northern hemisphere.

Five or six degrees S. W. of Arcturus are three stars of the 3d and 4th magnitudes, lying in a curved line, about 2° apart, and a little below the left knee of Bootes; and about 7° E. of Arcturus are three or four other stars of similar magnitude, situated in the other leg, making a larger curve N. and S.

Mirac, in the girdle, is a star of the 3d magnitude, 10° N. N. E. of Arcturus, and about 11½° W. of Alphacca, a star in the Northern Crown. *Seginus*, in the west shoulder, is a star of the 3d magnitude, nearly 20° E. of Cor Caroli, and about the same distance N. of Arcturus, and forms with these two, a right-angled triangle, the right angle being at Seginus. The same star forms a right-angled triangle with Cor Caroli and Alioth, in Ursa Major, the right angle being at Cor Caroli.

Alkaturops, situated in the top of the club, is a star of the 4th magnitude, about 10½° in an easterly direction from Seginus, which lies in the left shoulder; and about 4½° S. of Alkaturops is another star of the 4th magnitude, in the club near the east shoulder, marked *Delta*. Delta is about 9° distant from Mirac, and 7½° from Alphacca, and forms, with these two, a regular triangle.

Nekkar is a star of the 3d magnitude, situated in the head, and is about 6° N. E. of Seginus, and 5° W. of Alkaturops; it forms with Delta and Seginus, nearly a right angled triangle, the right angle being at Nekkar.

These are the principal stars in this constellation, except the three stars of the 4th magnitude situated in the right hand. These stars may be known by two of them being close together, and about 5° beyond Benetnasch, the first star

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How is this constellation situated? How many stars does it contain? How large are the principal ones? What is its mean right ascension? What is its mean declination? When is its center on the meridian? How is it easily distinguished from the surrounding constellations? Describe Arcturus. What is its situation with respect to Denebola and Spica Virginis? How is it situated with respect to Cor Caroli and Denebola? *What remarkable configuration in this part of the sky?* What is the distance of Arcturus from the earth, compared with that of the other stars in the northern hemisphere? *What stars five or six degrees south-west of Arcturus? What stars in the other leg? Describe the star Mirac. Describe Seginus. With what other stars does Seginus form a right-angled triangle? Describe the position of Alkaturops. Describe the position of Delta. Describe Nekkar.*

in the handle of the Dipper. About 6° E. of Benetnasch is another star of the 4th magnitude, situated in the arm, which forms, with Benetnasch and the three in the hand, an equilateral triangle.

The three stars in the left hand of Bootes, the first in the handle of the Dipper, Cor Caroli, Coma Berenices, and Denebola, are all situated nearly in the same right line, running from north-east to south-west.

"Bootes follows with redundant light;
Fifty four stars he boasts; one guards the Bear,
Thence call'd *Arcturus*, of resplendent front,
The pride of the *first order:* eight are veil'd,
Invisible to the unaided eye."

MANILIUS thus speaks of this constellation:—

"And next Bootes comes, whose order'd beams
Present a figure driving of his teams.
Below his girdle, near his knees, he bears
The bright *Arcturus*, fairest of the stars."

Arcturus is mentioned by name in that beautiful passage in Job, already referred to, where the Almighty answers "out of the whirlwind," and says:—

"Canst thou the sky's benevolence restrain,
And cause the Pleiades to shine in vain?
Or, when Orion sparkles from his sphere,
Thaw the cold seasons and unbind the year?
Bid Mazzaroth his station know,
And teach the bright *Arcturus* where to glow?"
Young's Paraphrase.

HISTORY.—The ancient Greeks called this constellation Lycaon—a name derived from λυκος, which signifies a *wolf*. The Hebrews called it *Caleb Anubach*, the "Barking Dog;" while the Latins, among other names, called it *Canis*. If we go back to the time when Taurus opened the year, and when Virgo was the fifth of the zodiacal signs, we shall find that brilliant star Arcturus, so remarkable for its red and fiery appearance, corresponding with a period of the year as remarkable for its heat. Pythagoras, who introduced the true system of the universe into Greece, received it from Œnuphis, a priest of On, in Egypt. And this college of the priesthood was the noblest of the east, in cultivating the studies of philosophy and astronomy. Among the high honors which Pharaoh conferred on Joseph, he very wisely gave him in marriage "a daughter of the priest of On." The supposed era of the book of Job, in which *Arcturus* is repeatedly mentioned, is 1513 B. C.

Bootes is supposed by some to be Icarus, the father of Erigone, who was killed by shepherds for intoxicating them. Others maintain that it is Erichthonius, the inventor of chariots. According to Grecian fable, as well as later authorities, Bootes was the son of Jupiter and Calisto, and named Arcas. Ovid relates, that Juno, being incensed at Jupiter for his partiality to Calisto, changed her into a bear, and that her son Arcas, who became a famous hunter, one day roused a bear in the chase, and not knowing that it was his mother, was about to kill her, when Jupiter snatched them both up to heaven and placed them among the constellations. Met. b. ii. v 496–508.

"But now her son had fifteen summers told,
Fierce at the chase, and in the forest bold;
When as he beat the woods in quest of prey,
He chanced to rouse his mother where she lay.
She knew her son, and kept him in her sight,
And fondly gazed: the boy was in a fright,
And aim'd a pointed arrow at her breast;
And would have slain his mother in the beast;
But Jove forbad, and snatch'd them through the air
In whirlwinds up to heaven, and fix'd 'em there;

Describe the three stars in the left hand of Bootes. What stars in this neighborhood form a long line through the heavens? Where is Arcturus mentioned in the Scriptures?

Where the new constellations nightly rise,
And add a luster to the northern skies."
Garth's Translation.

Lucan, in his *Pharsalia*, says,

"That Brutus. on the busy times intent,
To virtuous Cato's humble dwelling went
'Twas when the solemn dead of night came on,
When bright *Calisto, with her shining son,*
Now half that circle round the pole had run."

This constellation is called *Bootes*, says Cicero, (*Nat. Deo. Lib. ii.* 42,) from a Greek word signifying a wagoner, or ploughman; and sometimes *Arctophylax* from two Greeks words signifying bear-keeper or bear-driver.

"Arctophylax, vulgo qui dicitur esse Bootes.
Quod quasi temone adjunctum præ se quatit Arctum."

The stars in this region of the skies seem to have attracted the admiration of almost all the eminent writers of antiquity. Claudian observes, that

"Bootes with his wain the north unfolds;
The southern gate Orion holds."

And Aratus,* who flourished nearly 800 years before Claudian, says,

"Behind, and seeming to urge on the Bear,
Arctophylax, on earth Bootes named,
Sheds o'er the Arctic car his silver light."

CENTAURUS.

The Centaur.—This fabulous monster is represented by

* This is the poet whom St. Paul refers to when he tells the Athenians, Acts xvii 28, that "some of their own poets have said," "Του γαρ και γενος εσμεν: For we are also his offspring." These words are the beginning of the 5th line of the "Phenomena" of Aratus, a celebrated Greek poem written in the reign of Ptolemy Philadelphus, two thousand one hundred years ago, and afterward translated into Latin verse by Cicero. Aratus was a poet of St Paul's own country. The apostle borrows again from the same poet, both in his Epistle to the Galatians, and to Titus. The *subject* of the poem was grand and interesting: hence we find it referred to in the writings of St. Clement, St. Jerome, St. Chrysostom, Œcumenius, and others. As this poem describes the nature and motions of the stars, and the origin of the constellations, and is, moreover, one of the oldest compositions extant upon this interesting subject, the author has taken some pains to procure a Polyglot copy *from Germany*, together with the *Astronomicon* of Manilius, and some other works of similar antiquity, that nothing should be wanting on his part which could impart an interest to the study of the constellations, or illustrate the frequent allusions to them which we meet with in the Scriptures.

Dr. Doddridge says of the above quotation, that "these words are well known to be found in Aratus, a poet of Paul's own country, who lived almost 300 years before the apostle's time; and that the same words, with the alteration of only one letter, are to be found in the *Hymn of Cleanthes*, to Jupiter, the *Supreme God;* which is, beyond comparison, the purest and finest piece of *natural religion*, of its length, which I know in the whole world of Pagan antiquity; and which, so far as I can recollect, contains nothing unworthy of a Christian, or, I had almost said, of an inspired pen. The apostle might perhaps refer to *Cleanthes*, as well as to his countryman Aratus."

Many of the elements and fables of heathen mythology are so blended with the inspired writings, that they must needs be studied, more or less, in order to have a more proper understanding of numerous passages both in the Old and New Testament.

The great apostle of the Gentiles, in uttering his inspired sentiments, and in penning his epistles, often refers to, and sometimes quotes verbatim from the distinguished writers who preceded him.

Thus, in 1 Cor. xv. 33, we have "Μη πλανασθε· 'Φθειρουσιν ηθη χρησθ' ομιλιαι κακαι.' Be not deceived; evil communications corrupt good manners;" which is a literal quotation by the apostle from the Thais of Menander, an inventor of Greek comedy, and a celebrated Athenian poet, who flourished nearly 400 years before the apostle wrote his epistle to the Corinthians. Thus Paul adopts the sentiment of the comedian, and it becomes hallowed by "the divinity that stirred within him." Tertullian remarks, that "in quoting this, the apostle hath sanctified the poet's sentiment."

How is the Centaur represented?

the figure of a man terminating in the body of a horse, holding a wolf at arm's length in one hand, while he transfixes its body with a spear in the other.

Although this constellation occupies a large space in the southern hemisphere, yet it is so low down that the main part of it cannot be seen in our latitude. It is situated south of Spica Virginis, with a mean declination of 50°. It contains thirty-five stars, including two of the 1st magnitude, one of the 2d, and six of the 3d; the brightest of which are not visible in the United States.

Theta, is a star of between the 2d and 3d magnitude, in the east shoulder, and may be seen from this latitude, during the month of June, being about 27° S. by E. from Spica Virginis, and 12° or 13° above the southern horizon. It is easily recognized in a clear evening, from the circumstance that there is no other star of similar brightness in the same region, for which it can be mistaken. It is so nearly on the same meridian with Arcturus that it culminates but ten minutes before it.

Iota is a star of between the 4th and 5th magnitude, in the west shoulder, $9\frac{1}{2}$° W. of Theta. It is about 26° almost directly south of Spica Virginis, and is on the meridian nearly at the same time.

Mu and *Nu* are stars of the 4th magnitude, in the breast, very near together, and form a regular triangle with the two stars in the shoulders.

A few degrees north of the two stars in the shoulders, are four small stars in the head. The relative position of the stars in the head and shoulders is very similar to that of the stars in the head and shoulders of Orion.

History.—Centaurs, in mythology, were a kind of fabulous monsters, half men and half horses. This fable is, however, differently interpreted; some suppose the Centaurs to have been a body of shepherds and herdsmen, rich in cattle, who inhabited the mountains of Arcadia, and to whom is attributed the invention of pastoral poetry. But Plutarch and Pliny are of opinion that such monsters have really existed. Others say, that under the reign of Ixion, king of Thessaly, a herd of bulls ran mad, and ravaged the whole country, rendering the mountains inaccessible; and that some young men, who had found the art of taming and mounting horses, undertook to expel these noxious animals, which they pursued on horseback, and thence obtained the appellation of *Centaurs*.

This success rendering them insolent, they insulted the Lapithæ, a people of Thessaly; and because, when attacked, they fled with great rapidity, it was supposed that they were half horses and half men; men on horses being at that period a very uncommon sight, and the two appearing, especially at a distance, to constitute but one animal. So the Spanish calvary at first seemed to the astonished Mexicans, who imagined the horse and his rider, like the Centaurs of the ancients, to be some monstrous animal of a terrible form.

The Centaurs, in reality, were a tribe of Lapithæ, who resided near Mount Pelion, and first invented the art of breaking horses, as intimated by Virgil.

"The Lapithæ to chariots add the state
Of bits and bridles; taught the steed to bound
To turn the ring, and trace the mazy ground;
To stop, to fly, the rules of war to know;
To obey the rider, and to dare the foe."

LUPUS.

The Wolf.—This constellation is situated next east of the Centaur, and south of Libra; and is so low down in the

What is the situation of this constellation? What are the number and magnitude of its stars? *Describe the situation of Theta. How is it easily recognized in a clear evening? What is its distance from the meridian of Arcturus? Describe the star in the west shoulder. Describe the stars in the breast.* Where is the Wolf situated?

southern hemisphere, that only a few stars in the group are visible to us.

It contains twenty-four stars, including three of the 3d magnitude, and as many of the 4th; the brightest of which, when on the meridian, may be seen in a clear evening, just above the southern horizon. Their particular situation, however, will be better traced out by reference to the map than by written directions.

The most favorable time for observing this constellation is toward the latter end of June.

History.—This constellation, according to fable, is Lycaon, king of Arcadia, who lived about 3,600 years ago, and was changed into a wolf by Jupiter, because he offered human victims on the altars of the god Pan. Some attribute this metamorphosis to another cause. The sins of mankind, as they relate, had become so enormous, that Jupiter visited the earth to punish its wickedness and impiety. He came to Arcadia, where he was announced as a god, and the people began to pay proper adoration to his divinity. Lycaon, however, who used to sacrifice all strangers to his wanton cruelty, laughed at the pious prayers of his subjects; and to try the divinity of the god, served up human flesh on his table. This impiety so offended Jupiter, that he immediately destroyed the house of Lycaon, and changed him into a wolf.

"Of these he murders one; he boils the flesh,
And lays the mangled morsels in a dish;
Some part he roasts; then serves it up, so dress'd,
And bids me welcome to his human feast.
Moved with disdain, the table I o'erturn'd,
And with avenging flames the palace burn'd.
The tyrant in a fright for shelter gains
The neighboring fields, and scours along the plains:
Howling he fled, and fain he would have spoke,
But human voice his brutal tongue forsook.
His mantle, now his hide, with rugged hairs,
Cleaves to his back; a famish'd face he bears;
His arms descend, his shoulders sink away
To multiply his legs for chase of prey;
He grows a wolf."—*Ovid. Met.* B. i

LIBRA.

The Balance.—This is the seventh sign, and eighth constellation, from the vernal equinox, and is situated in the Zodiac, next east of Virgo.

The sun enters this *sign*, at the autumnal equinox, on the 23d of September; but does not reach the *constellation* before the 27th of October.

Virgo was the goddess of justice, and Libra, the scales, which she is usually represented as holding in her left hand, are the appropriate emblem of her office. When the sun enters the sign Libra, the days and nights are equal all over

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How many stars does it contain? Under what circumstances may the brightest of them be seen? How may the stars in this group be most conveniently traced out? When is the most favorable time for observing this constellation? How is Libra situated among the constellations of the Zodiac? At what season of the year does the sun enter Libra? Who was Virgo, and what was the emblem of her office? What is the relative length of the days and nights when the sun enters Libra?

the world, and seem to observe a kind of equilibrium, like a balance.

When, however, it is said that the vernal and autumnal equinoxes are in Aries and Libra, and the tropics in Cancer and Capricorn, it must be remembered that the *signs* Aries and Libra, Cancer and Capricorn, and not the constellations of these names, are meant; for the equinoxes are now in the constellations Pisces and Virgo, and the tropics in Gemini and Sagittarius; *each constellation having gone forward one sign in the ecliptic.*

About 22 centuries ago, the *constellation* Libra coincided with the *sign* Libra; but having advanced 30° or more in the ecliptic, it is now in the *sign* Scorpio, and the constellation Scorpio is in the *sign* Sagittarius, and so on.

While Aries is now advanced a whole sign above the equinoctial point into north declination, Libra has descended as far below it into south declination.

Libra contains fifty-one stars, including two of the 2d magnitude, two of the 3d, and twelve of the 4th. Its mean declination is 8° south, and its mean right ascension 226°. Its center is therefore on the meridian about the 22d of June.

It may be known by means of its four principal stars, forming a quadrilateral figure, lying north-east and south-west, and having its upper and lower corners nearly in a line running north and south. The two stars which form the N. E. side of the square, are situated about 7° apart, and distinguish the Northern Scale. The two stars which form the S. W. side of the square, are situated about 6° apart, and distinguish the Southern Scale.

Zubeneschamali, in the Southern Scale, about 21° E. of Spica, and 8° E. of Lambda Virginis, is a star of the 2d magnitude, and is situated very near the ecliptic, about 42½° E. of the autumnal equinox. The distance from this star down to Theta Centauri is about 23°, with which, and Spica Virginis, it forms a large triangle, on the right.

Zubenelgemabi, the uppermost star in the Northern Scale, is also of the 2d magnitude, 9½° above Zubeneschamali, toward the north-east, and it comes to the meridian about twenty-six minutes after it, on the 23d of June. Zubenelgemabi is the northernmost of the four bright stars in this figure, and is exactly opposite the lower one, which is 11° south of it.

Zubenhakrabi is a star of the 3d magnitude in the Northern Scale, 7° S. E. of Zubenelgemabi, and nearly opposite to Zubeneschamali, at the distance of 11° on the east. These two make the diagonal of the square east and west.

Iota is a star of the 4th magnitude, and constitutes the southernmost corner of

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When it is said that the vernal and autumnal equinoxes are in Aries and Libra, and the tropics in Cancer and Capricorn, what is meant? In what constellations, then, are the equinoxes and the tropics situated? When did the *constellation* of Libra coincide with the *sign* of that name? In what sign is the constellation Libra now situated? What are the number and magnitude of the stars in Libra? What are its right ascension and declination? When is its center on the meridian? How may this constellation be known? What figure do the three upper stars in this figure form? What stars distinguish the Northern Scale? What the Southern? *Describe Zubeneschamali. With what other stars does it form a large triangle? Describe the principal star in the Northern Scale. Describe the position of Zubenhakrabi. Describe the position of Iota.*

the square. It is about 6° S. E. of Zubeneschamali, and 11° S. of Zubenelgemabi, with which it forms the other diagonal north and south.

Zebenelgubi, is a star of the 3d magnitude, situated below the Southern Scale, at the distance of 6° from Iota, and marks the southern limit of the Zodiac. It is situated in a right line with, and nearly midway between Spica Virginis and Beta Scorpionis; and comes to the meridian nearly at the same moment with Nekkar, in the head of Bootes.

The remaining stars in this constellation are too small to engage attention.

The scholar, in tracing out this constellation in the heavens, will perceive that Lambda and Mu, which lie in the feet of Virgo on the west, form, with Zubeneschamali and Zubenelgemabi, almost as handsome and perfect a figure, as the other two stars in the Balance do on the east.

History.—The Libra of the Zodiac, says Maurice, in his Indian Antiquities, is perpetually seen upon all the hieroglyphics of Egypt; which is at once an argument of the great antiquity of this asterism, and of the probability of its having been originally fabricated by the astronomical sons of Misraim. In some few zodiacs, Astræa, or the virgin who holds the balance in her hand as an emblem of equal justice, is not drawn. Such are the zodiacs of Esne and Dendera. Humboldt is of opinion, that although the Romans introduced this constellation into their zodiac in the reign of Julius Cesar, still it might have been used by the Egyptians and other nations of very remote antiquity.

It is generally supposed that the figure of the balance has been used by all nations to denote the equality of the days and nights, at the period of the sun's arriving at this sign. It has also been observed, that at this season there is a greater uniformity in the temperature of the air all over the earth's surface.

Others affirm, that the *beam* only of the balance was at first placed among the stars, and that the Egyptians thus honored it as their *Nilometer*, or instrument by which they measured the inundations of the Nile. To this custom of measuring the waters of the Nile, it is thought the prophet alludes, when he describes the Almighty as *measuring the waters in the hollow of his hand.*—Isa. xl. 12.

The ancient husbandmen, according to Virgil, were wont to regard this sign as indicating the proper time for sowing their winter grain :—

"But when Astræa's balance, hung on high,
Betwixt the nights and days divides the sky,
Then yoke your oxen, sow your winter grain,
Till cold December comes with driving rain."

The Greeks declare that the balance was placed among the stars to perpetuate the memory of Mochus, the inventor of weights and measures.

Those who refer the constellations of the Zodiac to the twelve tribes of Israel ascribe the Balance to Asher.

SERPENS.

The Serpent.—There are no less than four kinds of serpents placed among the constellations. The first is the Hydra, which is situated south of the Zodiac, below Cancer, Leo and Virgo; the second is Hydrus, which is situated near the south pole; the third is Draco, which is situated about the north pole; and the fourth is the serpent called Serpens Ophiuchi, and is situated chiefly between Libra and Corona Borealis. A large part of this constellation, however, is so blended with Ophiuchus, the Serpent-Bearer, who grasps it in both hands, that the concluding description of it will be deferred until we come to that constellation.

"The *Serpens Ophiuchi* winds his spire
Immense: fewer by *ten* his figure trace;

What star in this constellation marks the southern limit of the Zodiac? How many kinds of serpents have been placed among the constellations? Mention them and their situations. With what is a large part of this constellation blended?

One of the second rank ; ten shun the sight ;
And seven, he who bears the monster hides."

Those stars which lie scattered along for about 25°, in a serpentine direction between Libra and the Crown, mark the body and head of the Serpent.

About 10° directly S. of the Crown there are three stars of the 3d magnitude, which, with several smaller ones, distinguish the head.

Unuk, of the 2d magnitude, is the principal star in this constellation. It is situated in the heart, about 10° below those in the head, and may be known by its being in a line with, and between, two stars of the 3d magnitude—the lower one, marked *Epsilon*, being 2½°, and the upper one, marked *Delta*, about 5½° from it. The direction of this line is N. N. W. and S. S. E. Unuk may otherwise be known by means of a small star, just above it, marked *Lambda*.

In that part of the Serpent which lies between Corona Borealis and the Scales, about a dozen stars may be counted, of which five or six are conspicuous.

For the remainder of this constellation, the student is referred to Serpentarius.

" Vast as the starry Serpent, that on high
Tracks the clear ether, and divides the sky,
And southward winding from the Northern Wain,
Shoots to remoter spheres its glittering train."—*Statius*.

HISTORY.—The Hivites, of the Old Testament, were worshipers of the Serpent, and were called *Ophites*. The idolatry of these Ophites was extremely ancient, and was connected with *Sabeism*, or the worship of the host of heaven. The heresy of the Ophites, mentioned by Mosheim in his Ecclesiastical History, originated, perhaps, in the admission into the Christian church of some remnant of the ancient and popular sect of Sabeists, who adored the celestial Serpent.

According to ancient tradition, Ophiuchus is the celebrated physician Æsculapius, son of Apollo, who was instructed in the healing art by Chiron the Centaur ; and the serpent, which is here placed in his hands, is understood by some to be an emblem of his sagacity and prudence ; while others suppose it was designed to denote his skill in healing the bite of this reptile. Biblical critics imagine that this constellation is alluded to in the following passage of the book of Job :—

"By his spirit He hath garnished the heavens ; his hand hath formed the crooked serpent." Mr. Green supposes, however, that the inspired writer here refers to Draco, because it is a more obvious constellation, being nearer the pole where the constellations were more universally noticed ; and moreover, because it is a more ancient constellation than the Serpent, and the hieroglyphic by which the Egyptians usually represented the heavens.

CORONA BOREALIS.

THE NORTHERN CROWN.—This beautiful constellation may be easily known by means of its six principal stars, which are so placed as to form a circular figure, very much resem-

What stars mark the head and body of the Serpent? Describe the principal star in this constellation. How may it be known? What stars distinguish the head? How many stars may be counted in that part of the constellation which lies between Corona Borealis and the Scales? How may Corona Borealis be easily known?

bling a wreath or crown. It is situated directly north of the Serpent's head, between Bootes on the west, and Hercules on the east.

This asterism was known to the Hebrews by the name of *Ataroth*, and by this name the stars in Corona Borealis are called, in the East, to this day.

Alphacca, of the 2d magnitude, is the brightest and middle star in the diadem, and about 11° E. of Mirac, in Bootes. It is very readily distinguished from the others both on account of its position and superior brilliancy. Alphacca, Arcturus, and Seginus, form nearly an isosceles triangle, the vertex of which is at Arcturus.

This constellation contains twenty-one stars, of which only six or eight are conspicuous; and most of these are not larger than the 3d magnitude. Its mean declination is 30° north, and its mean right ascension 235°; its center is therefore on the meridian about the last of June, and the first of July.

> "And, near to *Helice*, effulgent rays
> Beam, *Ariadne*, from thy starry crown:
> *Twenty* and *one* her stars; but eight alone
> Conspicuous; *one* doubtful, or to claim
> The second order, or accept the third."

History.—This beautiful little cluster of stars is said to be in commemoration of a crown presented by Bacchus to Ariadne, the daughter of Minos, second king of Crete. Theseus, king of Athens. (1235 B. C.,) was shut up in the celebrated labyrinth of Crete, to be devoured by the ferocious Minotaur which was confined in that place, and which usually fed upon the chosen young men and maidens exacted from the Athenians as a yearly tribute to the tyranny of Minos; but Theseus slew the monster, and being furnished with a clew of thread by Ariadne, who was passionately enamored of him, he extricated himself from the difficult windings of his confinement.

He afterward married the beautiful Ariadne, according to promise. and carried her away; but when he arrived at the island of Naxos, he deserted her, notwithstanding he had received from her the most honorable evidence of attachment and endearing tenderness. Ariadne was so disconsolate upon being abandoned by Theseus, that, as some say, she hanged herself; but Plutarch says that she lived many years after, and was espoused to Bacchus, who loved her with much tenderness, and gave her a crown of seven stars, which, after her death, was placed among the stars.

> "Resolves, for this the dear engaging dame
> Should shine forever in the rolls of fame;
> And bids her crown among the stars be placed,
> And with an eternal constellation graced.
> The golden circlet mounts; and, as it flies,
> Its diamonds twinkle in the distant skies;
> There, in their pristine form, the gemmy rays
> Between Alcides and the Dragon blaze."

Manilius, in the first book of his *Astronomicon*, thus speaks of the Crown.

> "Near to Bootes the bright Crown is view'd
> And shines with stars of different magnitude:

Where is it situated? Describe the principal star in the group. What geometrical figure is formed by the stars in this neighborhood? What are the number and magnitude of the stars in this constellation? What are its mean declination and right ascension? When is it on our meridian?

> Or placed in front above the rest displays
> A vigorous light, and darts surprising rays.
> This shone, since Theseus first his faith betray'd,
> The monument of the forsaken maid."

URSA MINOR.

The Little Bear.—This constellation, though not remarkable in its appearance, and containing but few conspicuous stars, is, nevertheless, justly distinguished from all others for the peculiar advantage which its position in the heavens is well known to afford to nautical astronomy, and especially to navigation and surveying.

The stars in this group being situated near the celestial pole, appear to revolve about it, very slowly, and in circles so small as never to descend below the horizon.

In all ages of the world, this constellation has been more universally observed, and more carefully noticed than any other, on account of the importance which mankind early attached to the position of its principal star.

This star which is so near the true pole of the heavens, has, from time immemorial, been denominated the North Polar Star. By the Greeks it is called *Cynosyre ;* by the Romans, *Cynosura*, and by other nations, *Alruccabah.*

It is of the 3d magnitude, or between the 2d and 3d, and situated a little more than a degree and a half from the true pole of the heavens, on that side of it which is toward Cassiopeia and opposite to Ursa Major. Its position is pointed out by the direction of the two *Pointers*, Merak and Dubhe, which lie in the square of Ursa Major. A line joining Beta Cassiopeiæ, which lies at the distance of 32° on one side, and Megrez, which lies at the same distance on the other, will pass through the polar star.

So general is the popular notion, that the North Polar Star is the true pole of the world, that even surveyors and navigators, who have acquired considerable dexterity in the use of the compass and the quadrant, are not aware that it ever had any deviation, and consequently never make allowance for any. All calculations derived from the observed position of this star, which are founded upon the idea that its bearing is always due north of any place, are necessarily erroneous, since it is in this position only twice in twenty-four hours; once when above, and once when below the pole.

What renders Ursa Minor an important constellation? What is its situation with respect to the North Pole, and how do its stars appear to revolve around this pole? Why has this constellation been more universally observed, in all ages of the world, than any other? What is this star denominated? What are its magnitude and position? How is its position pointed out? How is it situated with respect to Megrez and Beta Cassiopeiæ? Is it generally considered to be the north pole of the heavens? Are calculations founded upon this notion correct?

According to the Nautical Almanac, the mean distance of this star from the true pole of the heavens, for the year 1833 is 1° 34′ 53″, and its mean right ascension is 1 hour and 19 seconds. Consequently, when the right ascension of the meridian of any place is 1 hour and 19 seconds, the star will be exactly on the meridian at that time and place, but 1° 34′ 53″ *above* the true pole. Six hours after, when the right ascension of the meridian is 7 hours and 19 seconds, the star will be at its greatest elongation, or 1° 34′ 53″ directly *west* of the true pole, and parallel to it, with respect to the horizon; and when the right ascension of the meridian is 13 hours and 19 seconds, the star will be again on the meridian, but at the distance of 1° 34′ 53″ directly *below* the pole.

In like manner, when the right ascension of the meridian is 19 hours and 19 seconds, the star will be at its greatest eastern elongation, or 1° 34′ 53″ *east* of the true pole; and when it has finished its revolution, and the right ascension of the meridian is 25 hours and 19 seconds, or, what is the same thing, 1 hour and 19 seconds, the star will now be on the meridian again, 1° 34′ 53″ above the pole.

N. B. The right ascension of the meridian or of the mid-heaven, is the distance of the first point of Aries from the meridian, at the time and place of observation. The right ascension of the meridian for any time is found by adding to the given time the sun's right ascension at the same time, and deducting 24 hours, when the sum exceeds 24 hours.

From the foregoing facts we learn, that from the time the star is on the meridian, above the pole, it deviates farther and farther from the true meridian, every hour, as it moves to the west, for the space of six hours, when it arrives at its greatest elongation west, whence it reapproaches the same meridian below the pole, during the next six hours, and is then again on the meridian; being thus alternately half the time west of the meridian, and half the time east of it.

Hence, it is evident that the surveyor who regulates his compass by the North Polar Star, must take his observation when the star is on the meridian, either above or below the pole, or make allowance for its altered position in every other situation. For the same reason must the navigator, who applies his quadrant to this star for the purpose of determining the latitude he is in, make a similar allowance, according as its altitude is greater or less than the true pole of the hea-

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What is the present distance of this star from the true pole of the heavens? What is its mean right ascension? When is it on the meridian, and what then is its bearing from the pole? What is its situation six hours afterward? What is its situation six hours after that? What is its situation when in its third quadrant? *What do you understand by the right ascension of the meridian, or of the mid-heaven? How do you find the right ascension of the mid-heaven?* In what manner does the north star deviate from the meridian during one revolution? How do these facts concern the surveyor?

vens; for we have seen that it is alternately half the time *above* and half the time *below* the pole.

The method of finding the latitude of a place from the altitude of the polar star, as it is very simple, is very often resorted to. Indeed, in northern latitudes, the situation of this star is more favorable for this purpose than that of any other of the heavenly bodies, because a single observation, taken at any hour of the night with a good instrument, will give the true latitude, without any calculation or correction, except that of its polar aberration.

If the polar star always occupied that point in the heavens which is directly opposite the north pole of the earth, it would be easy to understand how latitude could be determined from it in the northern hemisphere; for in this case, to a person on the equator, the poles of the world would be seen in the horizon. Consequently, the star would appear just visible in the northern horizon, without any elevation. Should the person now travel one degree toward the north, he would see one degree below the star, and he would think it had risen one degree.

And since we always see the whole of the upper hemisphere at one view, when there is nothing in the horizon to obstruct our vision, it follows that if we should travel 10° north of the equator, we should see just 10° below the pole, which would then appear to have risen 10°; and should we stop at the 42d degree of north latitude we should, in like manner, have our horizon just 42° below the pole, or the pole would appear to have an elevation of 42°. Whence we derive this general truth: *The elevation of the pole of the equator is always equal to the latitude of the place of observation.*

Any instrument, then, which will give us the altitude of the north pole, will give us also the latitude of the place.

The method of illustrating this phenomenon, is given in most treatises on the globe, and as adopted by teachers generally, is to tell the scholar that the north pole rises higher and higher, as he travels farther and farther toward it. In other words, whatever number of degrees he advances *toward* the north pole, so many degrees will it rise above his horizon. This is not only an obvious *error* in principle, but it misleads the apprehension of the pupil. It is *not* that the *pole is elevated*, but that our *horizon is depressed* as we advance toward the north. The same objection lies against the artificial globe; for it ought to be so fixed that the *horizon* might be raised or depressed, and the pole remain in its own invariable position.

Ursa Minor contains twenty-four stars, including three of the 3d magnitude and four of the 4th. The seven principal stars are so situated as to form a figure very much resembling that in the Great Bear, only that the *Dipper* is reversed, and about one half as large as the one in that constellation.

The first star in the handle, called *Cynosura*, or *Alruccabah*, is the polar star, around which the rest constantly revolve. The two last in the bowl of the Dipper, corresponding to the *Pointers* in the Great Bear, are of the 3d magni-

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Why is the method of finding the latitude by the polar star often resorted to? Why is the position of this star favorable to this purpose? *If the north star perfectly coincided with the north pole of the heavens where would it be seen from the equator? Should a person travel one degree north of the equator, where would the star appear then? Suppose he should travel 10 degrees north of the equator? Suppose he were to stop at the 42d degree of north latitude? What general truth results from these facts? What, then, is all we want, to find the latitude of any place? Of what advantage to a mariner is an instrument which will give the altitude of the pole?* What are the number and magnitude of the stars contained in Ursa Minor? What figure do the seven principal stars form? Describe the first in the handle of the Little Dipper. Describe the two last in the bowl of the Dipper tude, and situated about 15° from the pole. The brightest of them is called Kochab, which signifies an axle or hinge, probably in reference to its moving so near the axis of the earth.

Kochab may be easily known by its being the brightest and middle one of the three conspicuous stars forming a row, one of which is about 2°, and the other 3°, from Kochab. The two brightest of these are situated in the breast and shoulder of the animal, about 3° apart, and are called the *Guards* or *Pointers* of Ursa Minor. They are on the meridian about the 20th of June, but may be seen at all hours of the night, when the sky is clear.

Of the four stars which form the bowl of the Dipper, one is so small as hardly to be seen. They lie in a direction toward Gamma in Cepheus; but as they are continually changing their position in the heavens, they may be much better traced out from the map, than from description.

Kochab is about 25° distant from Benetnasch, and about 24° from Dubhe, and hence forms with them a very nearly equilateral triangle.

————"The Lesser Bear
Leads from the pole the lucid band: the stars
Which form this constellation, faintly shine,
Twice twelve in number; only one beams forth
Conspicuous in high splendor, named by Greece
The *Cynosure;* by us, the POLAR STAR."

HISTORY.—The prevailing opinion is that Ursa Major and Ursa Minor are the nymph Calisto and her son Arcas, and that they were transformed into bears by the enraged and imperious Juno, and afterward translated to heaven by the favor of Jupiter, lest they might be destroyed by the huntsmen.

The Chinese claim that the emperor Hong-ti, the grandson of Noah, first discovered the polar star, and applied it to purposes of navigation. It is certain that it was used for this purpose in a very remote period of antiquity. From various passages in the ancients, it is manifest that the Phenicians steered by Cynosura, or the Lesser Bear; whereas the mariners of Greece, and some other nations steered by the Greater Bear, called Helice, or Helix.

Lucan, a Latin poet, who flourished about the time of the birth of our Saviour, thus adverts to the practice of steering vessels by Cynosura:—

"Unstable Tyre now knit to firmer ground,
With Sidon for her purple shells renown'd,
Safe in the *Cynosure* their glittering guide
With well-directed navies stem the tide."
ROWE'S Translation, B. iii.

The following extracts from other poets contain allusions to the same fact:

"Phenicia, spurning Asia's bounding strand,
By the bright *Pole star's* steady radiance led,
Bade to the winds her daring sails expand,
And fearless plough'd old Ocean's stormy bed."
MAURICE'S *Elegy on Sir W. Jones.*

"Ye radiant signs, who from the ethereal plain
Sidonians guide, and *Greeks* upon the main,
Who from your poles all earthly things explore,
And never set beneath the western shore."
OVID'S *Tristia.*

How may Kochab be easily known? What are the position and name of the two brightest of these? When are they on the meridian? How is Kochab situated with respect to Benetnasch and Dubhe?

"Of all yon multitude of golden stars,
Which the wide rounding sphere incessant bears.
The cautious mariner relies on none,
But keeps him to the constant pole alone."
LUCAN'S Pharsalia, B. viii. v. 225.

Ursa Major and Ursa Minor are sometimes called *Triones*, and sometimes the Greater and Lesser Wains. In Pennington's Memoirs of the learned Mrs. Carter, we have the following beautiful lines:—

"Here, Cassiopeia fills a lucid throne,
There, blaze the splendors of the Northern Crown;
While the slow *Car*, the cold *Triones* roll
O'er the pale countries of the frozen pole:
Whose faithful beams conduct the wandering ship
Through the wide desert of the pathless deep."

Thales, an eminent geometrician and astronomer, and one of the seven wise men of Greece, who flourished six hundred years before the Christian era, is generally reputed to be the inventor of this constellation, and to have taught the use of it to the Phenician navigators; it is certain that he brought the knowledge of it with him from Phenice into Greece, with many other discoveries both in astronomy and mathematics.

Until the properties of the magnet were known and applied to the use of navigation, and for a long time after, the north polar star was the only sure guide. At what time the attractive powers of the magnet were first known, is not certain; they were known in Europe about six hundred years before the Christian era; and by the Chinese records, it is said that its polar attraction was known in that country at least one thousand years earlier.

CHAPTER IX.

DIRECTIONS FOR TRACING THE CONSTELLATIONS WHICH ARE ON THE MERIDIAN IN JULY.

SCORPIO.

THE SCORPION.—This is the eighth sign, and ninth constellation, in the order of the Zodiac. It presents one of the most interesting groups of stars for the pupil to trace out that is to be found in the southern hemisphere. It is situated southward and eastward of Libra, and is on the meridian the 10th of July.

The sun enters this *sign* on the 23d of October, but does not reach the *constellation* before the 20th of November. When astronomy was first cultivated in the East, the two solstices and the two equinoxes took place when the sun was in Aquarius and Leo, Taurus and Scorpio, respectively.

Scorpio contains, according to Flamsted, forty-four stars including one of the 1st magnitude, one of the 2d, and eleven of the 3d. It is readily distinguished from all others by the peculiar luster and the position of its principal stars.

Antares is the principal star, and is situated in the heart

What is the position of Scorpio, among the signs and constellations of the Zodiac How is it situated with respect to Libra, and when is it on our meridian? What are the number and magnitude of its stars? How is it readil distinguished from all others. Describe the principal star in this constellation.

of the Scorpion, about 19° east of Zubenelgubi, the southernmost star in the Balance. Antares is the most brilliant star in that region of the skies, and may be otherwise distinguished by its remarkably red appearance. Its declination is about 26° S. It comes to the meridian about three hours after Spica Virginis, or fifty minutes after Corona Borealis, on the 10th of July. It is one of the stars from which the moon's distance is reckoned for computing the longitude at sea.

There are four great stars in the heavens, *Fomalhaut*, *Aldebaran*, *Regulus*, and *Antares*, which formerly answered to the solstitial and equinoctial points, and which were much noticed by the astronomers of the East.

About 8½° north-west of Antares, is a star of the 2d magnitude, in the head of the Scorpion, called *Graffias*. It is but one degree north of the earth's orbit. It may be recognized by means of a small star, situated about a degree north-east of it, and also by its forming a slight curve with two other stars of the 3d magnitude, situated below it, each about 3° apart. The broad part of the constellation near Graffias, is powdered with numerous small stars, converging down to a point at Antares, and resembling in figure a boy's kite.

As you proceed from Antares, there are ten conspicuous stars, chiefly of the 3d magnitude, which mark the tail of the kite, extending down, first in a south south-easterly direction about 17°, thence easterly about 8° further, when they turn, and advance about 8° toward the north, forming a curve like a shepherd's crook, or the bottom part of the letter S. This crooked line of stars, forming the tail of the Scorpion, is very conspicuous, and may be easily traced.

The first star below Antares, which is the last in the back, is of only the 4th magnitude. It is about 2° south-east of Antares, and is denoted by the Greek name of T.

Epsilon, of the 3d magnitude, is the second star from Antares, and the first in the tail. It is situated about 7° below the star T, but inclining a little to the east.

Mu, of the 3d magnitude, is the third star from Antares. It is situated 4½° below Epsilon. It may otherwise be known by means of a small star close by it, on the left.

Zeta, of about the same magnitude, and situated about as far below Mu, is the fourth star from Antares. Here the line turns suddenly to the east.

Eta, also of the 3d magnitude, is the fifth star from Antares, and about 3½° east of Zeta.

Theta, of the same magnitude, is the sixth star from Antares, and about 4½° east of Eta. Here, the line turns again, curving to the north, and terminates in a couple of stars.

Iota is the seventh star from Antares, 3½° above Theta, curving a little to the left. It is a star of the 3d magnitude, and may be known by means of a small star, almost touching it, on the east.

Kappa, a star of equal brightness, is less than 2° above Iota, and a little to the right.

How is Antares otherwise distinguished? What is its declination? What is the time of its passing the meridian? What nautical importance is attached to its position? Describe Graffias? How may it be recognized? What is the appearance of the constellation between Graffias and Antares? How many conspicuous stars below Antares? What are their magnitude and general direction? *Describe the first star below Antares. Describe the second star below Antares. Describe the third star, and tell how it may be known. Describe the fourth. Describe the fifth. Describe Theta. Describe Iota. Describe Kappa.*

Lesuth, of the 3d magnitude, is the brightest of the two last in the tail, and is situated about 3° above Kappa, still further to the right. It may readily be known by means of a smaller star, close by it, on the west.

This is a very beautiful group of stars, and easily traced out in the heavens. It furnishes striking evidence of the facility with which most of the constellations may be so accurately delineated, as to preclude every thing like uncertainty in the knowledge of their relative situation.

"The heart with luster of amazing force,
Refulgent vibrates; faint the other parts,
And ill-defined by stars of meaner note."

HISTORY.—This sign was anciently represented by various symbols, sometimes by a snake, and sometimes by a crocodile; but most commonly by the scorpion. This last symbol is found on the Mithraic monuments, which is pretty good evidence that these monuments were constructed when the vernal equinox accorded with Taurus.

On both the zodiacs of Dendera, there are rude delineations of this animal; that on the portico differs considerably from that on the other zodiac, now in the Louvre.

Scorpio was considered by the ancient astrologers as a sign accursed. The Egyptians fixed the entrance of the sun into Scorpio as the commencement of the reign of Typhon, when the Greeks fabled the death of Orion. When the sun was in Scorpio, in the month of *Athyr*, as Plutarch informs us, the Egyptians inclosed the body of their god Osiris in an *ark*, or chest, and during this ceremony a great annual festival was celebrated. Three days after the priests had inclosed Osiris in the ark, they pretended to have found him again. The death of Osiris, then, was lamented when the sun in *Scorpio* descended to the lower hemisphere, and when he arose at the vernal equinox, then Osiris was said to be born anew.

The Egyptians or Chaldeans, who first arranged the Zodiac, might have placed Scorpio in this part of the heavens to denote that when the sun enters this sign, the diseases incident to the fruit season would prevail; since Autumn, which abounded in fruit, often brought with it a great variety of diseases, and might be thus fitly represented by that venomous animal, the scorpion, who, as he recedes, wounds with a sting in his tail.

Mars was the tutelary deity of the Scorpion, and to this circumstance is owing all that jargon of the astrologers, who say that there is a great analogy between the malign influence of the planet Mars and this sign. To this also is owing the doctrine of the alchemists, that iron, which metal they call Mars, is under the dominion of Scorpio; so that the transmutation of it into gold can be effected only when the sun is in this sign.

The constellation of the Scorpion is very ancient. Ovid thus mentions it in his beautiful fable of Phaeton:—

"There is a place above, where Scorpio bent,
In tail and arms surrounds a vast extent;
In a wide circuit of the heavens he shines,
And fills the place of two celestial signs."

According to Ovid, this is the famous scorpion which sprang out of the earth at the command of Juno, and stung Orion; of which wound he died. It was in this way the imperious goddess chose to punish the vanity of the hero and the hunter, for boasting that there was not on earth any animal which he could not conquer.

"Words that provoked the gods once from him fell,
'No beasts so fierce,' said he, 'but I can quell;'
When lo! the earth a baleful scorpion sent,
To kill Latona was the dire intent;
Orion saved her, though himself was slain,
But did for that a spacious place obtain
In heaven: '*to thee my life*,' said she, '*was dear*,
And *for thy merit shine illustrious there*.'"

Describe Lesuth.

Although both Orion and Scorpio were honored by the celestials with a place among the stars, yet their situations were so ordered that when one rose the other should set, and *vice versa;* so that they never appear in the same hemisphere at the same time.

In the Hebrew zodiac this sign is allotted to Dan, because it is written, "Dan shall be a serpent by the way, an adder in the path."

HERCULES.

Hercules is represented on the map invested with the skin of the Nemæan Lion, holding a massy club in his right hand, and the three-headed dog Cerberus in his left.

He occupies a large space in the northern hemisphere, with one foot resting on the head of Draco, on the north, and his head nearly touching that of Ophiuchus, on the south. This constellation extends from 12° to 50° north declination, and its mean right ascension is 255°; consequently its center is on the meridian about the 21st of July.

It is bounded by Draco on the north, Lyra on the east, Ophiuchus or the Serpent-Bearer on the south, and the Serpent and the Crown on the west.

It contains one hundred and thirteen stars, including one of the 2d, or of between the 2d and 3d magnitudes, nine of the 3d magnitude, and nineteen of the 4th. The principal star is *Ras Algethi*, and is situated in the head, about 25° south-east of Corona Borealis. It may be readily known by means of another bright star of equal magnitude, 5° east south-east of it, called Ras Alhague. Ras Alhague marks the head of Ophiuchus, and Ras Algethi that of Hercules. These two stars are always seen together, like the bright pairs in Aries, Gemini, the Little Dog, &c. They come to our meridian about the 28th of July, near where the sun does, the last of April, or the middle of August.

About midway between Ras Algethi on the south-east, and Ariadne's Crown on the north-west, may be seen Beta and Gamma. two stars of the 3d magnitude, situated in the west shoulder, about 3° apart. The northernmost of these two is called *Rutilicus.*

Those four stars in the shape of a diamond, 8° or 10° south-west of the two in the shoulder of Hercules, are situated in the head of the serpent.

About 12° E. N. E. of Rutilicus, and 10½° directly north of Ras Algethi, are two stars of the 4th magnitude, in the east shoulder. They may be known by two very minute stars a little above them on the left. The two stars in each shoulder of Hercules, with Ras Algethi in the head, form a regular triangle.

The left, or east arm of Hercules, which grasps the triple-headed monster Cerberus, may be traced by means of three or four stars of the 4th magnitude, situa-

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How is the constellation Hercules represented? What space does it occupy, and what is its situation in the heavens? What are its declination and right ascension? When is its center on the meridian? How is it bounded? What are the number and magnitude of its stars? Describe the principal star. What do Ras Algethi and Ras Alhague serve to mark? When are they on our meridian? *Describe the situation of Beta and Gamma. What is the northernmost of these two called? What four stars are situated* 8° *or* 10° *S. W. of the two in the shoulder? Describe the stars in the east shoulder. How may these be known? What geometrical figure do the stars in the head and shoulders of Hercules form? How may the left arm of Hercules be traced?*

ted in a row 3° and 4° apart, extending from the shoulder, in a north-easterly direction. That small cluster, situated in a triangular form, about 14° north-east of Ras Algethi, and 13° east south-east of the left shoulder, distinguish the head of Cerberus.

Eighteen or 20° north-east of the Crown, are four stars of the 3d and 4th magnitudes, forming an irregular square, of which the two southern ones are about 4° apart, and in a line 6° or 7° south of the two northern ones, which are nearly 7° apart.

Pi, in the north-east corner, may be known by means of one or two other small stars, close by it, on the east. *Eta*, in the north-west corner, may be known by its being in a row with two smaller stars, extending toward the north-west, and about 4° apart. The stars of the 4th magnitude, just south of the Dragon's head, point out the left foot and ankle of Hercules.

Several other stars, of the 3d and 4th magnitudes, may be traced out in this constellation, by reference to the map.

History.—This constellation is intended to immortalize the name of Hercules, the Theban, so celebrated in antiquity for his heroic valor and invincible prowess. According to the ancients, there were many persons of this name. Of all these, the son of Jupiter and Alcmena is the most celebrated, and to him the actions of the others have been generally attributed.

The birth of Hercules was attended with many miraculous events. He was brought up at Tirynthus, or at Thebes, and before he had completed his eighth month, the jealousy of Juno, who was intent upon his destruction, sent two snakes to devour him. Not terrified at the sight of the serpents, he boldly seized them, and squeezed them to death, while his brother Iphicles alarmed the house with his frightful shrieks.

He was early instructed in the liberal arts, and soon became the pupil of the centaur Chiron, under whom he rendered himself the most valiant and accomplished of all the heroes of antiquity. In the 18th year of his age, he commenced his arduous and glorious pursuits. He subdued a lion that devoured the flocks of his supposed father, Amphitryon. After he had destroyed the lion, he delivered his country from the annual tribute of a hundred oxen, which it paid to Erginus.

As Hercules, by the will of Jupiter, was subjected to the power of Eurystheus, and obliged to obey him in every respect, Eurystheus, jealous of his rising fame and power, ordered him to appear at Mycenæ, and perform the labors which, by priority of birth, he was empowered to impose upon him. Hercules refused, but afterward consulted the oracle of Apollo, and was told that he must be subservient, for twelve years, to the will of Eurystheus, in compliance with the commands of Jupiter; and that, after he had achieved the most celebrated labors, he should be reckoned in the number of the gods. So plain an answer determined him to go to Mycenæ, and to bear with fortitude whatever gods or men should impose upon him. Eurystheus, seeing so great a man totally subjected to him, and apprehensive of so powerful an enemy, commanded him to achieve a number of enterprises the most difficult and arduous ever known, generally called the Twelve Labors of Hercules. Being furnished with complete armor by the favor of the gods, he boldly encountered the imposed labors.

1. He subdued the Nemæan Lion in his den, and invested himself with his skin.
2. He destroyed the Lernæan Hydra, with a hundred hissing heads, and dipped his arrows in the gall of the monster to render their wounds incurable.
3. He took alive the stag with golden horns and brazen feet, so famous for its incredible swiftness, after pursuing it for twelve months, and presented it, unhurt, to Eurystheus.
4. He took alive the Erymanthian Boar, and killed the Centaurs who opposed him.
5. He cleansed the stables of Augias, in which 3000 oxen had been confined for many years.
6. He killed the carniverous birds which ravaged the country of Arcadia, and fed on human flesh.
7. He took alive, and brought into Peloponnesus, the wild bull of Crete, which no mortal durst look upon.

How is the head of Cerberus distinguished? There are four stars in the form of an irregular square, in the body of Hercules—describe them. Describe the situation of Pi. Describe the situation of Eta. What stars point out the left foot of Hercules?

8. He obtained for Eurystheus the mares of Diomedes, which fed on human flesh, after having given their owner to be first eaten by them.
9. He obtained the girdle of the queen of the Amazons, a formidable nation of warlike females.
10. He killed the monster Geryon, king of Gades, and brought away his numerous flocks, which fed upon human flesh.
11. He obtained the golden apples from the garden of the Hesperides, which were watched by a dragon.
12. And finally, he brought up to the earth the three-headed dog Cerberus, the guardian of the entrance to the infernal regions.

According to Dupuis, the twelve labors of Hercules are only a figurative representation of the annual course of the *sun* through the twelve signs of the Zodiac; Hercules being put for the sun, inasmuch as it is the powerful planet which animates and imparts fecundity to the universe, and whose divinity has been honored, in every quarter, by temples and altars, and consecrated in the religious strains of all nations.

Thus Virgil, in the eighth book of his Æneid, records the deeds of Hercules, and celebrates his praise :—

"The lay records the labors, and the praise,
And all the immortal acts of Hercules.
First, how the mighty babe, when swath'd in bands,
The serpents strangled with his infant hands;
Then, as in years and matchless force he grew,
The Œchalian walls and Trojan overthrew
Besides a thousand hazards they relate,
Procured by Juno's and Eurystheus' hate.
Thy hands, unconquer'd hero, could subdue
The cloud-born Centaurs, and the monster crew;
Nor thy resistless arm the bull withstood;
Nor he, the roaring terror of the wood.
The triple porter of the Stygian seat
With lolling tongue lay fawning at thy feet,
And, seized with fear, forgot the mangled meat.
The infernal waters trembled at thy sight:
Thee, god, no face of danger could affright;
Nor huge Typhæus, nor the unnumber'd snake,
Increased with hissing heads, in Lerna's lake."

Besides these arduous labors which the jealousy of Eurystheus imposed upon him, he also achieved others of his own accord, equally celebrated. Before he delivered himself up to the king of Mycenæ he accompanied the Argonauts to Colchis. He assisted the gods in their wars against the giants, and it was through him alone that Jupiter obtained the victory. He conquered Laomedon and pillaged Troy.

At three different times he experienced fits of insanity. In the second, he slew the brother of his beloved Iole; in the third he attempted to carry away the sacred tripod from Apollo's temple at Delphi, for which the oracle told him he must be sold as a slave. He was sold accordingly to Omphale, queen of Lydia, who restored him to liberty, and married him. After this he returned to Peloponnesus, and re-established on the throne of Sparta his friend Tyndarus, who had been expelled by Hippocoon. He became enamored of Dejanira, whom, after having overcome all his rivals, he married; but was obliged to leave his father-in-law's kingdom, because he had inadvertently killed a man with a blow of his fist. He retired to the court of Ceyx, king of Trachina, and in his way was stopped by the streams of the Evenus, where he slew the Centaur Nessus, for presuming to offer indignity to his beloved Dejanira. The Centaur, on expiring, gave to Dejanira the celebrated tunic which afterward caused the death of Hercules. "This tunic," said the expiring monster, "has the virtue to recall a husband from unlawful love." Dejanira, fearing lest Hercules should relapse again into love for the beautiful Iole, gave him the fatal tunic, which was so infected with the poison of the Lernæan Hydra, that he had no sooner invested himself with it, than it began to penetrate his bones, and to boil through all his veins He attempted to pull it off, but it was too late.

"As the red iron hisses in the flood,
So boils the venom in his curdling blood.
Now with the greedy flame his entrails glow,
And livid sweats down all his body flow;

The crackling nerves, burnt up, are burst in twain,
The lurking venom melts his swimming brain."

As the distemper was incurable, he implored the protection of Jupiter, gave his bow and arrows to Philoctetes, and erected a large burning pile on the top of Mount Œta. He spread on the pile the skin of the Nemæan lion, and laid himself down upon it, as on a bed, leaning his head upon his club. Philoctetes set fire to the pile, and the hero saw himself, on a sudden, surrounded by the most appalling flames; yet he did not betray any marks of fear or astonishment. Jupiter saw him from heaven, and told the surrounding gods, who would have drenched the pile with tears, while they entreated that he would raise to the skies the immortal part of a hero who had cleared the earth from so many monsters and tyrants; and thus the thunderer spake :—

———" Be all your fears forborne :
The Œtean fires do thou, great hero, scorn.
Who vanquish'd all things shall subdue the flame
That part alone of gross maternal frame
Fire shall devour; while what from me he drew
Shall live immortal, and its force subdue :
That, when he's dead, I'll raise to realms above ; —
May all the powers the righteous act approve."
Ovid's Met. lib. ix.

Accordingly, after the mortal part of Hercules was consumed, as the ancient poets say, he was carried up to heaven in a chariot drawn by four horses.

"Quem pater omnipotens inter cava nubila raptum,
Quadrijugo curru radiantibus intulit astris."

——— "Almighty Jove
In his swift car his honor'd offspring drove;
High o'er the hollow clouds the coursers fly,
And lodge the hero in the starry sky."
Ovid's Met. lib. ix. v. 271.

SERPENTARIUS, VEL OPHIUCHUS.

THE SERPENT-BEARER is also called Æsculapius, or the god of medicine. He is represented as a man with a venerable beard, having both hands clenched in the folds of a prodigious serpent, which is writhing in his grasp.

The constellation occupies a considerable space in the mid-heaven, directly south of Hercules, and west of Taurus Poniatowski. Its center is very nearly over the equator, opposite to Orion, and comes to the meridian the 26th of July. It contains seventy-four stars, including one of the 2d magnitude, five of the 3d, and ten of the 4th.

The principal star in Serpentarius is called *Ras Alhague*. It is of the 2d magnitude, and situated in the head, about 5° E. S. E. of Ras Algethi, in the head of Hercules. Ras Alhague is nearly 13° N. of the equinoctial, while *Rho*, in the southern foot, is about 25° south of the equinoctial. These two stars serve to point out the extent of the constellation from north to south. Ras Alhague comes to the meridian on the 28th of July, about 21 minutes after Ras Algethi.

How is the constellation Serpentarius represented? What is its extent, and where is it situated? When is its center on the meridian? What are the number and magnitude of its stars? What are the name and position of its principal star? What two stars mark the extremes of the constellation, north and south? When is Ras Alhague on the meridian?

About 10° S. W. of Ras Alhague are two small stars of the 4th magnitude, scarcely more than a degree apart. They distinguish the left or west shoulder. The northern one is marked *Iota*, and the other *Kappa*.

Eleven or twelve degrees S. S. E. of Ras Alhague are two other stars of the 3d magnitude, in the east shoulder, and about 2° apart. The upper one is called *Cheleb*, and the lower one *Gamma*. These stars in the head and shoulders of Serpentarius. form a triangle, with the vertex in Ras Alhague, and pointing toward the north-east.

About 4° E. of Gamma, is a remarkable cluster of four or five stars, in the form of the letter V, with the open part to the north. It very much resembles the Hyades. This beautiful little group mark the face of TAURUS PONIATOWSKI. The solstitial colure passes through the equinoctial about 2° E. of the lower star in the vertex of the V. The letter name of this star is *k*. There is something remarkable in its central position. It is situated almost exactly in the mid-heavens, being nearly equidistant from the poles, and midway between the vernal and autumnal equinoxes. It is, however, about one and a third degrees nearer the north than the south pole, and about two degrees nearer the autumnal than the vernal equinox, being about two degrees west of the solstitial colure.

Directly south of the V, at the distance of about 12°, are two very small stars, about 2° apart, situated in the right hand, where it grasps the serpent. About half-way between. and nearly in a line with, the two in the hand and the two in the shoulder, is another star of the 3d magnitude, marked *Zeta*, situated in the Serpent, opposite the right elbow. It may be known by means of a minute star just under it.

Marsic, in the left arm, is a star of the 4th magnitude, about 10° S. W. of Iota and Kappa. About 7° farther in the same direction are two stars of the 3d magnitude, situated in the hand, and a little more than a degree apart. The upper one of the two, which is about 16° N. of Graffias in Scorpio, is called *Yed;* the other is marked Epsilon. These two stars mark the other point in the folds of the monster where it is grasped by Serpentarius.

The left arm of Serpentarius may be easily traced by means of the two stars in the shoulder, the one (Marsic) near the elbow, and the two in the hand; all lying nearly in a line N. N. E. and S. S. W. In the same manner may the right arm be traced, by stars very similarly situated: that is to say, first by the two in the east shoulder, just west of the V, thence 8° in a southerly direction inclining a little to the east, by Zeta, (known by a little star right under it,) and then by the two small ones in the right hand, situated about 6° below Zeta.

About 12° from Antares, in an easterly direction, are two stars in the right foot, about 2° apart. The largest and lower of the two. is on the left hand. It is of between the 3d and 4th magnitudes, and marked *Rho*. There are several other stars in this constellation of the 3d and 4th magnitudes. They may be traced out from the maps.

"Thee, Serpentarius, we behold distinct,
With *seventy-four* refulgent stars; and *one*
Graces thy helmet, of the second class:
The *Serpent*, in thy hand grasp'd, winds his spire
Immense; fewer by *ten* his figure trace;

Describe the stars in the west shoulder of Serpentarius. What stars distinguish the east shoulder? How are these two stars denominated? What is the relative position of the stars in the head and shoulders? What remarkable cluster of stars in this neighborhood? To what constellation does this group belong? How is this cluster situated with respect to the solstitial colure? What is remarkable in the central position of Kappa? *Describe the stars in the right hand of Serpentarius. Describe the situation of Zeta. Describe Marsic, and the two stars in the left hand. Which of the two is called Yed, and how is it situated? How may the left arm of Serpentarius be traced? How may the right arm be traced? Describe the stars in the right foot of Serpentarius. What other stars may be traced out in this constellation?*

One of the second rank; ten shun the sight;
And seven, he who bears the monster hides."—*Eudosia.*

HISTORY.—This constellation was known to the ancients twelve hundred years before the Christian era. Homer mentions it. It is thus referred to in the Astronomicon of Manilius:—

"Next, Ophiuchus, strides the mighty snake,
Untwists his winding folds, and smooths his back,
Extends his bulk, and o'er the slippery scale
His wide-stretch'd hands on either side prevail
The snake turns back his head, and seems to rage:
That war must last where equal power prevails."

Æsculapius was the son of Apollo, by Coronis, and was educated by Chiron the Centaur in the art of medicine, in which he became so skillful, that he was considered the inventor and god of medicine. At the birth of Æsculapius, the inspired daughter of Chiron uttered, "in sounding verse," this prophetic strain:

"Hail, great physician of the world, all hail!
Hail, mighty infant, who, in years to come,
Shall heal the nations and defraud the tomb!
Swift be thy growth! thy triumphs unconfined!
Make kingdoms thicker, and increase mankind:
Thy daring art shall animate the dead,
And draw the thunder on thy guilty head:
Then shalt thou die, but from the dark abode
Rise up victorious, and be twice a god."

He accompanied the Argonauts to Colchis, in the capacity of physician. He is said to have restored many to life, insomuch that Pluto complained to Jupiter, that his dark dominion was in danger of being depopulated by his art.

Æsculapius was worshiped at Epidaurus, a city of Peloponnesus, and hence he is styled by Milton, "the god in Epidaurus." Being sent for to Rome in the time of a plague, he assumed the form of a serpent and accompanied the ambassadors, but though thus changed, he was Æsculapius still, *in serpente deus*—the deity in a serpent, and under that form he continued to be worshiped at Rome. The cock and the serpent were sacred to him, especially the latter. The ancient physicians used them in their prescriptions.

One of the last acts of Socrates, who is accounted the wisest and best man of Pagan antiquity, was to offer a cock to Æsculapius. He and Plato were both idolaters; they conformed, and advised others to conform, to the religion of their country; to gross idolatry and absurd superstition. If the wisest and most learned were so blind, what must the foolish and ignorant have been?

CHAPTER X.

DIRECTIONS FOR TRACING THE CONSTELLATIONS WHICH ARE ON THE MERIDIAN IN AUGUST.

DRACO.

THE DRAGON.—This constellation which compasses a large circuit in the polar regions by its ample folds and contortions, contains many stars which may be easily traced.

From the head of the monster, which is under the foot of Hercules, there is a complete coil tending eastwardly, about 17° N. of Lyra; thence he winds down northerly about 14°

What is the situation of the constellation Draco? Describe, if you please, the various coils of the Dragon.

to the second coil, where he reaches almost to the girdle of Cepheus, then he loops down somewhat in the shape of the letter U, and makes a third coil about 15° below the first. From the third coil he holds a westerly course for about 13°, then goes directly down, passing between the head of the Lesser and the tail of the Greater Bear.

This constellation contains eighty stars, including two of the 2d magnitude, three of the 3d, and sixteen of the 4th.

> "The *Dragon* next, winds like a mighty stream;
> Within its ample folds are *eighty* stars,
> Four of the second order. Far he waves
> His ample spires, involving either *Bear*."

The head of the Dragon is readily distinguished by means of four stars, 3°, 4°, and 5° apart, so situated as to form an irregular square; the two upper ones being the brightest, and both of the 2d magnitude. The right-hand upper one, called *Etanin*, has been rendered very noted in modern astronomy from its connection with the discovery of a new law in physical science, called the *Aberration of Light.*

The letter name of this star is *Gamma*, or *Gamma Draconis;* and by this appellation it is most frequently called. The other bright star, about 4° from it on the left, is *Rastaben.*

About 4° W. of Rastaben, a small star may, with close attention, be discerned in the nose of the Dragon, which, with the irregular square before mentioned, makes a figure somewhat resembling an Italic *V*, with the point toward the west, and the open part toward the east. The small star in the nose, is called *Er Rakis.*

The two small stars 5° or 6° S. of Rastaben are in the left foot of Hercules.

Rastaben is on the meridian nearly at the same moment with Ras Alhague. Etanin, 40° N. of it, is on the meridian about the 4th of August, at the same time with the three western stars in the face of Taurus Poniatowski, or the V. It is situated less than 2° west of the solstitial colure, and is exactly in the zenith of London. Its favorable position has led English astronomers to watch its appearance, for long periods, with the most exact and unwearied scrutiny.

In the year 1725, Mr. Molyneux and Dr. Bradley fitted up a very accurate and costly instrument, in order to discover whether the fixed stars had any sensible parallax, while the earth moved from one extremity of its orbit to the other; or which is the same, to determine whether the nearest fixed stars are situated at such an immense distance from the earth, that any star which is seen this night directly north of us, will, six months hence, when we shall have gone 190 mil-

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What is the course of the monster from the third coil? What are the number and magnitude of the stars contained in this constellation? How is the head of the Dragon distinguished? Which star is called Etanin, and for what is it noted? By what other appellation is it generally known? What stars in the head of Draco form the letter V, and how is it situated? When is Rastaben on the meridian? When is Etanin on the meridian, and what stars in this region culminate at the same time? How is Rastaben situated with respect to the solstitial colure and the zenith of London?

lions of miles to the eastward of the place we are now in, be then seen exactly north of us still, without changing its position so much as the thickness of a spider's web.

These observations were subsequently repeated, with but little intermission, for twenty years, by the most acute observers in Europe, and with telescopes varying from 12 feet to 36 feet in length. In the mean time, Dr. Bradley had the honor of announcing to the world the very nice discovery, that *the motion of light, combined with the progressive motion of the earth in its orbit, causes the heavenly bodies to be seen in a different position from what they would be, if the eye were at rest.* Thus was established the principle of the *Aberration of Light.*

This principle, or law, now that it is ascertained, seems not only very plain, but self-evident. For if light be progressive, the position of the telescope, in order to receive the ray, must be different from what it would have been, if light had been instantaneous, or if the earth stood still. Hence the place to which the telescope is directed, will be different from the true place of the object.

The quantity of this aberration is determined by a simple proposition. The earth describes 59′ 8″ of her orbit in a day=3548″, and a ray of light comes from the sun to us in 8′ 13″=493″ : now 24 hours or 86400″ : 493″ : : 3548″ : 22″; which is the change in the star's place, arising from the cause above mentioned.

Of the four stars forming the irregular square in the head, the lower and right-hand one is $5\frac{1}{2}$° N. of Etanin. It is called *Grumium*, and is of the 3d magnitude. A few degrees E. of the square, may be seen, with a little care, eight stars of the 5th magnitude, and one of the 4th, which is marked *Omicron*, and lies 8° E. of Grumium. This group is in the first coil of the Dragon.

The second coil is about 13° below the first, and may be recognized by means of four stars of the 3d and 4th magnitudes, so situated as to form a small square, about half the size of that in the head.

The brightest of them is on the left, and is marked Delta. A line drawn from Rastaben through Grumium, and produced about 14°, will point it out. A line drawn from Lyra through Zi Draconis, and produced 10° further, will point out *Zeta*, a star of the 3d magnitude, situated in the third coil. Zeta may otherwise be known, by its being nearly in a line with, and midway between, Etanin aud Kochab. From Zeta, the remaining stars in this constellation are easily traced.

Eta, Theta, and *Asich*, come next; all stars of the 3d magnitude, and at the distance, severally, of 6°, 4°, and 5° from Zeta. At Asich, the third star from Zeta, the tail of the Dragon makes a sudden crook. *Thuban*, *Kappa*, and *Giansar* follow next, and complete the tail.

Thuban is a bright star of the 2d magnitude, 11° from Asich, in a line with, and about midway between, Mizar and the southernmost guard in the Little Bear. By nautical men this star is called the *Dragon's Tail*, and is considered of much importance at sea. It is otherwise celebrated as being formerly the *north polar star.* About 2,300 years before the Christian era, Thuban was ten times nearer the true pole of the heavens than Cynosura now is.

Kappa is a star of the 3d magnitude, 10° from Alpha, between Megrez and the pole. Mizar and Megrez, in the tail of the Great Bear, form, with Thuban and Kappa, in the tail of the Dragon, a large quadrilateral figure, whose longest side is from Megrez to Kappa.

Giansar, the last star in the tail, is between the 3d and 4th magnitudes, and 5° from Kappa. The two pointers will also point out Giansar, lying at the distance of little more than 8° from them, and in the direction of the pole.

Describe the stars in the first coil of Draco. Describe the stars in the second coil. What is the brightest of this group called, and how may it be pointed out? What is the principal star of the third coil, and how may it be found? How else may Zeta be known? What stars come next to Zeta, in this constellation? What stars follow these? Describe Thuban. By what other name is this star known, and for what is it celebrated? When was Thuban within ten minutes of the pole? *Describe Kappa. What figure do Mizar and Megrez, in the tail of the Great Bear, form with Thuban and Kappa, in the tail of the Dragon? Describe the position of Giansar, and tell how it is pointed out.*

———" Here the vast *Dragon* twines
Between the Bears, and like a river winds—
The Bears, that still with fearful caution keep,
Untinged beneath the surface of the deep."
Warton's Virgil, G. i.

History.—Whoever attends to the situation of Draco, surrounding, as it does, the pole of the Ecliptic, will perceive that its tortuous windings are symbolical of the oblique course of the stars. Draco also winds round the pole of the world, as if to indicate, in the symbolical language of Egyptian astronomy, the motion of the pole of the Equator around the pole of the Ecliptic, produced by the precession of the heavens. The Egyptian hieroglyphic for the heavens, was a *serpent*, whose scales denoted the stars. When astronomy first began to be cultivated in Chaldea, Draco was the *polar constellation*.

Mythologists, however, give various accounts of this constellation; by some it is represented as the watchful dragon which guarded the golden apples in the famous garden of the Hesperides,* near Mount Atlas in Africa, and was slain by Hercules. Juno, who presented these apples to Jupiter on the day of their nuptials, took Draco up to heaven, and made a constellation of him, as a reward for his faithful services. Others maintain that in the war with the giants, this dragon was brought into combat, and opposed to Minerva, who seized it in her hand, and hurled it, twisted as it was, into the heavens round the axis of the world, before it had time to unwind its contortions, where it sleeps to this day. Other writers of antiquity say, that this is the dragon killed by Cadmus, who was ordered by his father to go in quest of his sister Europa, whom Jupiter had carried away, and never to return to Phenicia without her.

" When now Agenor had his daughter lost,
He sent his son to search on every coast;
And sternly bade him to his arms restore
The darling maid, or see his face no more."

His search, however, proving fruitless, he consulted the oracle of Apollo, and was ordered to build a city where he should see a heifer stop in the grass, and to call the country Bœotia. He saw the heifer according to the oracle, and as he wished to render thanks to the god by a sacrifice, he sent his companions to fetch water from a neighboring grove. The waters were sacred to Mars, and guarded by a most terrific dragon, who devoured all the messengers. Cadmus, tired of their seeming delay, went to the place, and saw the monster still feeding on their flesh.

" Deep in the dreary den, conceal'd from day,
Sacred to Mars, a mighty dragon lay,
Bloated with poison to a monstrous size:
Fire broke in flashes when he glanced his eyes;

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* Those who attempt to explain the mythology of the ancients, observe that the Hesperides were certain persons who had an immense number of flocks; and that the ambiguous Greek word μηλον, *melon*, which sometimes signifies an apple and sometimes a sheep, gave rise to the fable of the golden apple of these gardens.

The "Hesperian gardens famed of old," as Milton observes, were so called from *Hesperus Vesper*, because placed in the west, under the evening star. Some suppose them to have been situated near Mount Atlas, in Africa; others maintain that they were the isles about Cape Verd, whose most westerly point is still called *Hesperium Cornu*, the Horn of the Hesperides; while others contend, that they were the Canary Islands.

Atlas, said to have been contemporary with Moses, was king of Mauritania, in the north part of Africa, and owner of a thousand flocks of every kind. For refusing hospitality to Perseus, he was changed into the mountain that still bears his name; and which is so high, that the ancients imagined that the heavens rested upon its summit, and consequently, that Atlas supported the world on his shoulders. Virgil has this idea, where he speaks of "Atlas, whose brawny back supports the skies:" and Hesiod, verse 785, advances the same notion:—

" Atlas, so hard necessity ordains,
Erect, the ponderous vault of stars sustains,
Not far from the Hesperides he stands,
Nor from the load retracts his head or hands."

From this very ancient and whimsical notion, Atlas is represented by artists, and in works of mythology, as an old man bearing the world on his shoulders. Hence it is, that a collection of maps, embracing the whole world, is called an *Atlas*.

His towering crest was glorious to behold;
His shoulders and his sides were scaled with gold;
Three tongues he brandish'd when he charged his foes;
His teeth stood jaggy in three dreadful rows.
The Tyrians in the den for water sought,
And with their urns explored the hollow vault:
From side to side their empty urns rebound,
And rouse the sleeping serpent with their sound.
Straight he bestirs him, and is seen to rise;
And now with dreadful hissings fills the skies,
And darts his forky tongues, and rolls his glaring eyes.
The Tyrians drop their vessels in the fright,
All pale and trembling at the hideous sight.
Spire above spire uprear'd in air he stood,
And gazing round him, overlook'd the wood:
Then floating on the ground in circles roll'd;
Then leap'd upon them in a mighty fold.
All their endeavors and their hopes are vain;
Some die entangled in the winding train;
Some are devour'd, or feel a loathsome death,
Swollen up with blasts of pestilential breath."

Cadmus, beholding such a scene, boldly resolved to avenge, or to share their fate. He therefore attacked the monster with slings and arrows, and, with the assistance of Minerva. slew him. He then plucked out his teeth, and sowed them, at the command of Pallas, in a plain, when they suddenly sprung up into armed men.

"Pallas adest: motæque jubet supponere terræ
Viperos dentes, populi incrementa futuri.
Paret: et, ut presso sulcum pate ecit aratro,
Spargit humi jussos, mortalia semina dentes.
Inde (fide majus) glebæ cæpere moveri:
Primaque de sulcis acies apparuit hastæ
Tegmina mox capitum picto nutantia cono:
Existunt: crescitque seges clypeata virorum."
Ovid's Met. lib. iii. v. 102.

"He sows the teeth at Pallas's command,
And flings the future people from his hand.
The clods grow warm, and crumble where he sows;
And now the pointed spears advance in rows;
Now nodding plumes appear. and shining crests,
Now the broad shoulders and the rising breasts;
O'er all the field the breathing harvest swarms,
A growing host! a crop of men and arms!"

Entertaining worse apprehension from the direful offspring than he had done from the dragon himself, he was about to fly, when they fell upon each other, and were all slain in one promiscuous carnage, except five, who assisted Cadmus to build the city of Bœotia

LYRA.

THE HARP.—This constellation is distinguished by one of the most brilliant stars in the northern hemisphere. It is situated directly south of the first coil of Draco, between the Swan on the east, and Hercules on the west; and when on the meridian, is almost directly overhead.

It contains twenty-one stars, including one of the 1st magnitude, two of the 3d, and as many of the 4th.

By what is the constellation of the Harp distinguished? Where is it situated? What are the number and magnitude of its stars?

> "There *Lyra*, for the brightness of her stars,
> More than their number, eminent; thrice seven
> She counts, and *one* of these illuminates
> The heavens far around, blazing imperial
> In the *first* order."

This star of "the first order, blazing with imperial" luster, is called *Vega*, and sometimes *Wega;* but more frequently it is called *Lyra*, after the name of the constellation.

There is no possibility of mistaking this star for any other. It is situated $14\frac{2}{3}°$ S. E. of Etanin, and about 30° N. N. E. of Ras Alhague and Ras Algethi. It may be certainly known by means of two small, yet conspicuous stars, of the 5th magnitude, situated about 2° apart, on the east of it, and making with it a beautiful little triangle, with the angular point at Lyra.

The northernmost of these two small stars is marked *Epsilon*, and the southern one, *Zeta*. About 2° S. E. of Zeta, and in a line with Lyra, is a star of the 4th magnitude, marked *Delta*, in the middle of the Harp; and 4° or 5° S. of Delta, are two stars of the 3d magnitude, about 2° apart, in the garland of the Harp, forming another triangle, whose vertex is in Delta. The star on the east is marked *Gamma;* that on the west, *Beta*. If a line be drawn from Etanin through Lyra, and produced 6° farther, it will reach Beta.

This is a variable star, changing from the 3d to nearly the 5th magnitude in the space of a week; it is supposed to have spots on its surface, and to turn on its axis, like our sun.

Gamma comes to the meridian 21 minutes after Lyra, and precisely at the same moment with *Epsilon*, in the tail of the Eagle, $17\frac{1}{2}°$ S. of it.

The declination of Lyra is about $38\frac{2}{3}°$ N.; consequently when on the meridian, it is but 2° S. of the zenith of Hartford. It culminates at 9 o'clock, about the 13th of August. It is as favorably situated to an observatory at Washington, as Rastaben is to those in the vicinity of London.

Its surpassing brightness has attracted the admiration of astronomers in all ages. Manilius, who wrote in the age of Augustus, thus alludes to it:—

> "ONE, placed in front above the rest, displays
> A vigorous light and darts surprising rays."
>
> *Astronomicon*, B. i. p. 15.

HISTORY.—It is generally asserted that this is the celestial Lyre which Apollo or Mercury gave to Orpheus, and upon which he played with such a masterly hand, that even the most rapid rivers ceased to flow, the wild beasts of the forest forgot their wildness, and the mountains came to listen to his song.

Of all the nymphs who used to listen to his song, Eurydice was the only one who made a deep impression on the musician, and their nuptials were celebrated. Their happiness, however, was short. Aristæus became enamored of Eurydice, and as she fled from her pursuer, a serpent, lurking in the grass, bit her foot, and she died of the wound. Orpheus resolved to recover her, or perish in the attempt. With his lyre in his hand, he entered the infernal regions, and gained admission to Pluto. The king of hell was charmed with his strains, the wheel

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What is the name of the principal star? Describe its position. By what means may it be certainly known? *What are the names of the two small stars forming the base of the triangle? Describe the star in the middle of the Harp, and those with which it forms another triangle. How are the stars in the base of this triangle marked on the map? How else may Beta be pointed out? What is there remarkable in the appearance of this star? When is Gamma on the meridian?* What is the declination of Lyra? When does it culminate? What ancient poet mentions it?

of Ixion stopped, the stone of Sisyphus stood still, Tantalus forgot his thirst, and even the furies relented.

Pluto and Proserpine were moved, and consented to restore him Eurydice, provided he forbore looking behind him till he had come to the extremest borders of their dark dominions. The condition was accepted, and Orpheus was already in sight of the upper regions of the air, when he forgot, and turned back to look at his long-lost Eurydice. He saw her, but she instantly vanished from his sight. He attempted again to follow her, but was refused admission.

From this time Orpheus separated himself from the society of mankind, which so offended the Thracian women, it is said, that they tore his body to pieces, and threw his head into the Hebrus, still articulating the words Eurydice! Eurydice! as it was carried down the stream into the Ægean sea. Orpheus was one of the Argonauts, of which celebrated expedition he wrote a poetical account, which is still extant. After his death, he received divine honors, and his lyre became one of the constellations.

This fable, or allegory, designed merely to represent the power of music in the hands of the great master of the science, is similarly described by three of the most renowned Latin poets. Virgil, in the fourth book of his Georgics, thus describes the effect of the lyre:—

"E'en to the dark dominions of the night
He took his way, through forests void of light,
And dared amid the trembling ghosts to sing,
And stood before the inexorable king.
The infernal troops like passing shadows glide,
And listening, crowd the sweet musician's side;
Men, matrons, children, and the unmarried maid,
The mighty hero's more majestic shade,
And youth, on funeral piles before their parents laid.
E'en from the depths of hell the damn'd advance;
The infernal mansions, nodding, seem to dance;
The gaping three-mouth'd dog forgets to snarl;
The furies hearken, and their snakes uncurl;
Ixion seems no more his pain to feel,
But leans attentive on his standing wheel.
All dangers past, at length the lovely bride
In safety goes, with her melodious guide."

Pythagoras and his followers represent Apollo playing upon a harp of seven strings, by which is meant (as appears from Pliny, b. ii. c. 22, Macrobius i. c. 19, and Censorinus c. ii.), the sun in conjunction with the seven planets; for they made him the leader of that septenary chorus, and the moderator of nature, and thought that by his attractive force he acted upon the planets in the harmonical ratio of their distances.

The doctrine of celestial harmony, by which was meant the music of the spheres, was common to all the nations of the East. To this divine music Euripides beautifully alludes:—"Thee I invoke, thou self-created Being, who gave birth to Nature, and whom light and darkness, and the whole train of globes encircle with eternal music."—So also Shakspeare:—

———"Look, how the floor of heaven
Is thick inlaid with patines of bright gold;
There's not the smallest orb which thou behold'st,
But in his motion like an angel sings,
Still quiring to the young-eyed cherubim:
Such harmony is in immortal souls;
But, while this muddy vesture of decay
Doth grossly close it in, we cannot hear it."

The lyre was a famous stringed instrument, much used among the ancients, said to have been invented by Mercury about the year of the world 2000; though some ascribe the invention to Jubal. (Genesis iv. 21.) It is universally allowed, that the lyre was the first instrument of the string kind ever used in Greece. The different lyres, at various periods of time, had from four to eighteen strings each. The modern lyre is the Welsh harp. The lyre, among painters, is an attribute of Apollo and the Muses.

All poetry, it has been conjectured, was in its origin lyric; that is, adapted to recitation or song, with the accompaniment of music, and distinguished by the utmost boldness of thought and expression; being at first employed in celebrating the praises of gods and heroes.

Lesbos was the principal seat of the Lyric Muse; and Terpander, a native of this island, who flourished about 650 years B. C., is one of the earliest of the lyric poets whose name we find on record. Sappho, whose misfortunes have united with her talents to render her name memorable, was born at Mitylene, the chief city of Lesbos. She was reckoned a tenth muse, and placed without controversy at the head of the female writers in Greece. But Pindar, a native of Thebes, who flourished about 500 years B. C., is styled the prince of lyric poets. To him his fellow-citizens erected a monument; and when the Lacedemonians ravaged Bœotia, and burnt the capital, the following words were written upon the door of the poet: FORBEAR TO BURN THIS HOUSE IT WAS THE DWELLING OF PINDAR.

SAGITTARIUS.

THE ARCHER.—This is the ninth sign and the tenth constellation of the Zodiac. It is situated next east of Scorpio, with a mean declination of 35° S. or 12° below the ecliptic.

The sun enters this *sign* on the 22d of November, but does not reach the *constellation* before the 7th of December.

It occupies a considerable space in the southern hemisphere, and contains a number of subordinate, though very conspicuous stars. The whole number of its visible stars is sixty-nine, including five of the 3d magnitude, and ten of the 4th.

It may be readily distinguished by means of five stars of the 3d and 4th magnitudes, forming a figure resembling a little, short, straight-handled dipper, turned nearly bottom upward, with the handle to the west, familiarly called the *Milk-Dipper*, because it is partly in the Milky-Way.

This little figure is so conspicuous that it cannot easily be mistaken. It is situated about 33° E. of Antares, and comes to the meridian a few minutes after Lyra, on the 17th of August. Of the four stars forming the bowl of the Dipper, the two upper ones are only 3° apart, and the lower ones 5°.

The two smaller stars forming the handle, and extending westerly about 4½°, and the easternmost one in the bowl of the Dipper, are all of the 4th magnitude. The star in the end of the handle, is marked *Lambda*, and is placed in the bow of Sagittarius, just within the Milky-Way. Lambda may otherwise be known by its being nearly in a line with two other stars about 4½° apart, extending toward the S E. It is also equidistant from *Phi* and *Delta*, with which it makes a handsome triangle, with the vertex in Lambda. About 5° above Lambda, and a little to the west, are two stars close together, in the end of the bow, the brightest of which is of the 4th magnitude, and marked *Mu*. This star serves to point out the winter solstice, being about 2° N. of the tropic of Capricorn, and less than one degree east of the solstitial colure.

If a line be drawn from Sigma through Phi, and produced about 6° farther to the west, it will point out *Delta*, and produced about 3° from Delta, it will point

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What is the order in the Zodiac of Sagittarius? How is it situated? When does the sun appear to enter this constellation? What are its extent and appearance? What are the number and magnitude of its stars? How may it be readily distinguished? What is this figure called, and why? Where is this figure to be found, and when is it on the meridian? How far apart are the two upper stars in the bowl of the Dipper? How far apart are the two lower ones? *Describe the stars in the handle. Describe the position of Lambda. How may Lambda be otherwise known? With what other stars does it form a handsome triangle? Describe the position of Mu. How may Delta and Gamma be pointed out?*

out *Gamma;* stars of the 3d magnitude, in the arrow. The latter is in the point of the arrow, and may be known by means of a small star just above it, on the right. This star is so nearly on the same meridian with Etanin, in the head of Draco, that it culminates only two minutes after it.

A few other conspicuous stars in this constellation, forming a variety of geometrical figures, may be easily traced from the map.

History.—This constellation, it is said, commemorates the famous Centaur Chiron. son of Philyra and Saturn, who changed himself into a horse, to elude the jealous inquiries of his wife Rhea.

Chiron was famous for his knowledge of music, medicine and shooting. He taught mankind the use of plants and medicinal herbs; and instructed, in all the polite arts, the greatest heroes of his age. He taught Æsculapius physic, Apollo music, and Hercules astronomy; and was tutor to Achilles, Jason, and Æneas. According to Ovid, he was slain by Hercules, at the river Evenus, for offering indignity to his newly married bride.

"Thou monster double shap'd, my right set free—
Swift as his words, the fatal arrow flew:
The Centaur's back admits the feather'd wood,
And through his breast the barbed weapon stood;
Which, when in anguish, through the flesh he tore,
From both the wounds gush'd forth the spumy gore."

The arrow which Hercules thus sped at the Centaur, having been dipped in the blood of the Lernæan Hydra, rendered the wound incurable, even by the father of medicine himself, and he begged Jupiter to deprive him of immortality, if thus he might escape his excruciating pains. Jupiter granted his request, and translated him to a place among the constellations.

"Midst golden stars he stands refulgent now,
And thrusts the scorpion with his bended bow."

This is the Grecian account of Sagittarius; but as this constellation appears on the ancient zodiacs of Egypt, Dendera, Esne, and India, it seems conclusive that the Greeks only *borrowed the figure*, while they *invented the fable.* This is known to be true with respect to very many of the ancient constellations. Hence the jargon of the conflicting accounts which have descended to us.

AQUILA ET ANTINOUS.

The Eagle and Antinous.—This double constellation is situated directly south of the Fox and Goose, and between Taurus Poniatowski on the west, and the Dolphin on the east. It contains seventy-one stars, including one of the 1st magnitude, nine of the 3d, and seven of the 4th. It may be readily distinguished by the position and superior brilliancy of its principal star.

Altair, the principal star in the Eagle, is of the 1st, or between the 1st and 2d magnitudes. It is situated about 14° S. W. of the Dolphin. It may be known by its being the largest and middle one of the three bright stars which are arranged in a line bearing N. W. and S. E. The stars on each side of Altair are of the 3d magnitude, and distant from it about 2°. This row of stars very much resembles that in the Guards of the Lesser Bear.

How is Gamma situated with respect to Etanin? In what part of the heavens is the Eagle situated? What are the number and magnitude of its stars? How is it distinguished? Describe its principal star. How may it be known? What is the magnitude of the stars on each side of Altair? How far distant from it are they? What row of stars does this row resemble?

Altair is one of the stars from which the moon's distance is taken for computing longitude at sea. Its mean declination is nearly 8½° N., and when on the meridian, it occupies nearly the same place in the heavens that the sun does at noon on the 12th day of April. It culminates about 6 minutes before 9 o'clock, on the last day of August. It rises *acronically* about the beginning of June.

Ovid alludes to the rising of this constellation; or, more probably, to that of the principal star, Altair:—

———"Now view the skies,
And you'll behold Jove's hook'd-bill bird arise."

Massey's Fasti.

———"Among thy splendid group
ONE dubious whether of the SECOND RANK,
Or to the FIRST entitled; but whose claim
Seems to deserve the FIRST."

Eudosia.

The northernmost star in the line, next above Altair, is called *Tarazed.* In the wing of the Eagle, there is another row composed of three stars, situated 4° or 5° apart, extending down toward the south-west; the middle one in this line is the smallest, being only of the 4th magnitude; the next is of the 3d magnitude, marked *Delta*, and situated 8° S. W. of Altair.

As you proceed from Delta, there is another line of three stars of the 3d magnitude, between 5° and 6° apart, extending southerly, but curving a little to the west, which mark the youth Antinous. The northern wing of the Eagle is not distinguished by any conspicuous stars.

Zeta and *Epsilon*, of the 3d magnitude, situated in the tail of the Eagle, are about 2° apart, and 12° N. W. of Altair. The last one in the tail, marked Epsilon, is on the same meridian, and culminates the same moment with Gamma, in the Harp.

From Epsilon, in the tail of the Eagle, to Theta, in the wrist of Antinous, may be traced a long line of stars, chiefly of the 3d magnitude, whose letter names are Theta, Eta, Mu, Zeta, and Epsilon. The direction of this line is from S. E. to N. W., and its length is about 25°.

Eta is remarkable for its *changeable* appearance. Its greatest brightness continues but 40 hours; it then gradually diminishes for 66 hours when its luster remains stationary for 30 hours. It then waxes brighter and brighter, until it appears again as a star of the 3d magnitude.

From these phenomena, it is inferred that it not only has spots on its surface, like our sun, but that it also turns on its axis.

Similar phenomena are observable in Algol, Beta, in the Hare, Delta, in Cepheus, and Omicron, in the Whale, and many others.

———"Aquila the next,
Divides the ether with her ardent wing:
Beneath the *Swan* nor far from *Pegasus*,
POETIC EAGLE."

HISTORY.—Aquila, or the Eagle, is a constellation usually joined with Antinous. Aquila is supposed to have been Merops, a king of the island of Cos, in the Archipelago, and the husband of Clymene, the mother of Phaeton; this monarch having been transformed into an eagle, and placed among the constellations. Some have imagined that Aquila was the eagle whose form Jupiter assumed when he carried away Ganymede; others, that it represents the eagle which brought nectar to Jupiter while he lay concealed in the cave at Crete, to avoid

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Of what importance is this star at sea? What is its declination? What place does it occupy in the heavens when on the meridian, and when does it culminate? When does it rise acronically? *Describe the position of Tarazed. Describe the row of stars in the wing of the Eagle. Describe the row of stars which mark the youth Antinous. What stars in the northern wing? Describe Zeta and Epsilon. When is Epsilon on the meridian? What long line of stars terminates at Epsilon? What are the direction and extent of this line? Describe the remarkable appearance of Eta. What is inferred from these phenomena?*

the fury of his father, Saturn. Some of the ancient poets say, that this is the eagle which furnished Jupiter with weapons in his war with the giants:—

"The towering *Eagle* next doth boldly soar,
As if the thunder in his claws he bore;
He's worthy Jove, since he, a bird, supplies
The heaven with sacred bolts, and arms the skies."
Manilius.

The eagle is justly styled the "sovereign of birds," since he is the largest, strongest, and swiftest of all the feathered tribe that live by prey. Homer calls the eagle, "the strong sovereign of the plumy race;" Horace styles him—

"The royal bird, to whom the king of heaven
The empire of the feathered race has given:"

And Milton denominates the eagle the "Bird of Jove." Its sight is quick, strong and piercing, to a proverb: Job xxix. 28, &c.

"Though strong the hawk, though practiced well to fly,
An eagle drops her in the lower sky;
An eagle when deserting human sight,
She seeks the sun in her unwearied flight;
Did thy command her yellow pinion lift
So high in air, and set her on the clift
Where far above thy world she dwells alone,
And proudly makes the strength of rocks her own;
Thence wide o'er nature takes her dread survey,
And with a glance predestinates her prey?
She feasts her young with blood; and hovering over
The unslaughtered host, enjoys the promised gore."

ANTINOUS.

Antinous is a part of the constellation Aquila, and was invented by Tycho Brahe. Antinous was a youth of Bithynia, in Asia Minor. So greatly was his death lamented by the emperor Adrian, that he erected a temple to his memory, and built in honor of him a splendid city, on the banks of the Nile, the ruins of which are still visited by travelers with much interest.

CHAPTER XI.

DIRECTIONS FOR TRACING THE CONSTELLATIONS WHICH ARE ON THE MERIDIAN IN SEPTEMBER.

DELPHINUS.

THE DOLPHIN.—This beautiful little cluster of stars is situated 13° or 14° N. E. of the Eagle. It consists of eighteen stars, including four of the 3d magnitude, but none larger. It is easily distinguished from all others, by means of the four principal stars in the head, which are so arranged as to form the figure of a diamond, pointing N. E. and S. W. To many, this cluster is known by the name of *Job's Coffin;* but from whom, or from what fancy, it first obtained this appellation, is not known.

Where is the constellation Delphinus situated? What are the number and magnitude of its stars? How is this constellation distinguished from all others? What singular name is sometimes given to this cluster, and whence was it derived?

There is another star of the 3d magnitude, situated in the body of the Dolphin, about 3° S. W. of the Diamond, and marked *Epsilon*. The other four are marked *Alpha*, *Beta*, *Gamma*, *Delta*. Between these are several smaller stars, too small to be seen in presence of the moon.

The mean declination of the Dolphin is about 15° N. It comes to the meridian the same moment with Deneb Cygni, and about 50 minutes after Altair, on the 16th of September.

> " Thee I behold, majestic *Cygnus*,
> On the marge dancing of the heavenly sea,
> Arion's friend; eighteen thy stars appear—
> *One* telescopic."

HISTORY.—The Dolphin, according to some mythologists, was made a constellation by Neptune, because one of these beautiful fishes had persuaded the goddess Amphitrite, who had made a vow of perpetual celibacy, to become the wife of that deity; but others maintain, that it is the dolphin which preserved the famous lyric poet and musician Arion, who was a native of Lesbos, an island in the Archipelago.

He went to Italy with Periander, tyrant of Corinth, where he obtained immense riches by his profession. Wishing to revisit his native country, the sailors of the ship in which he embarked resolved to murder him, and get possession of his wealth. Seeing them immovable in their resolution, Arion begged permission to play a tune upon his lute before he should be put to death. The melody of the instrument attracted a number of dolphins around the ship; he immediately precipitated himself into the sea; when one of them, it is asserted, carried him safe on his back to Tænarus, a promontory of Laconia, in Peloponnesus; whence he hastened to the court of Periander, who ordered all the sailors to be crucified at their return.

> " But, (past belief.) a dolphin's arched back
> Preserved Arion from his destined wrack;
> Secure he sits, and with harmonious strains
> Requites his bearer for his friendly pains."

When the famous poet Hesiod was murdered in Naupactum, a city of Ætolia, in Greece, and his body thrown into the sea, some dolphins, it is said, brought back the floating corpse to the shore, which was immediately recognized by his friends; and the assassins being afterward discovered by the dogs of the departed bard, were put to death by immersion in the same sea.

Taras, said by some to have been the founder of Tarentum, now Tarento, in the south of Italy, was saved from shipwreck by a dolphin; and the inhabitants of that city preserved the memory of this extraordinary event on their coin.

The natural shape of the dolphin, however, is not incurvated, so that one might ride upon its back, as the poets imagined, but almost straight. When it is first taken from the water, it exhibits a variety of exquisitely beautiful but evanescent tints of color, that pass in succession over its body until it dies. They are an extremely swift-swimming fish, and are capable of living a long time out of water; in fact, they seem to delight to gambol, and leap out of their native element.

> " Upon the swelling waves the dolphins show
> Their bending backs; then swiftly darting go.
> And in a thousand wreaths their bodies show."

CYGNUS.

THE SWAN—This remarkable constellation is situated in the Milky-Way, directly E. of Lyra, and nearly on the same

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Mention some other stars in the Dolphin. What is the mean declination of the Dolphin, and when is it on the meridian? In what part of the heavens is the constellation Cygnus situated?

meridian with the Dolphin. It is represented on outspread wings, flying down the Milky-Way, toward the south-west.

The principal stars which mark the wings, the body and the bill of Cygnus, are so arranged, as to form a large and regular *Cross;* the upright piece lying along the Milky-Way from N. E. to S. W., while the *cross piece*, representing the wings, crosses the other at right angles, from S. E. to N. W.

Arided, or *Deneb Cygni*, in the body of the Swan, is a star of the second magnitude, 24° E. N. E. of Lyra, and 30° directly N. of the Dolphin. It is the most brilliant star in the constellation. It is situated at the upper end of the cross, and comes to the meridian at 9 o'clock on the 16th of September.

Sad'r is a star of the 3d magnitude, 6° S. W. of Deneb, situated exactly in the cross, or where the upright piece intersects the cross piece, and is about 20° E. of Lyra.

Delta, the principal star in the west wing, or arm of the cross, is situated N. W. of Sad'r, at the distance of little more than 8°, and is of the 3d magnitude. Beyond Delta, toward the extremity of the wing, are two smaller stars about 5° apart, and inclining a little obliquely to the north; the last of which reaches nearly to the first coil of Draco. These stars mark the west wing; the east wing may be traced by means of stars very similarly situated.

Gienah is a star of the 3d magnitude, in the east wing, just as far east of Sad'r in the center of the cross, as Delta is west of it. This row of three equal stars, Delta, Sad'r, and Gienah, form the bar of the cross, and are equidistant from each other, being about 8° apart. Beyond Gienah on the east, at the distance of 6° or 7°, there are two other stars of the 3d magnitude; the last of which marks the extremity of the eastern wing.

The stars in the neck are all too small to be noticed. There is one, however, in the beak of the Swan, at the foot of the cross, called *Albireo*, which is of the 3d magnitude, and can be seen very plainly. It is about 16° S. W. of Sad'r, and about the same distance S. E. of Lyra, with which it makes nearly a right angle.

"In the small space between Sad'r and Albireo," says Dr. Herschel, "the stars in the Milky-Way seem to be clustering into two separate divisions; each division containing more than *one hundred and sixty-five thousand stars.*"

Albireo bears northerly from Altair about 20°. Immediately south and south-east of Albireo, may be seen the Fox and GOOSE; and about midway between Albireo and Altair, there may be traced a line of four or five minute stars, called the ARROW; the head of which is on the S. W., and can be distinguished by means of two stars situated close together.

According to the British catalogue, this constellation contains eighty-one stars, including one of the 1st or 2d magnitude, six of the 3d, and twelve of the 4th. The author of the following beautiful lines says there are one hundred and seven.

> "Thee, silver Swan, who, silent, can o'erpass?
> A *hundred* with *seven* radiant stars compose
> Thy graceful form: amid the lucid stream

How is it represented? What remarkable figure is formed by its principal stars? Describe the position and appearance of Arided, or Deneb Cygni. When does it culminate at 9 o'clock? *Describe the position of Sad'r. Describe Delta. What stars beyond Delta? What stars in the east wing? What stars form the bar of the cross? What stars beyond Gienah on the east? Describe the stars in the neck and bill of the Swan. How is the star in the bill situated with respect to Sad'r and Lyra? What clusters south and south-east of Albireo?* What are the number and magnitude of the stars in the Swan?

Of the fair Milky-Way distinguished; *one*
Adorns the *second* order, where she cuts
The waves that follow in her utmost track;
This never hides its fire throughout the night,
And of the rest, the more conspicuous mark
Her snowy pinions and refulgent neck."—*Eudosia*, b. iv.

Astronomers have discovered *three variable* stars in the Swan. *Chi*, situated in the neck, between Beta and Sad'r, was first observed to vary its brightness in 1686. Its periodical changes of light are now ascertained to be completed in 405 days. *Sad'r* is also changeable. Its greatest luster is somewhat less than that of a star of the 3d magnitude, and it gradually diminishes till it reaches that of the 6th. Its changes are far from being regular, and, from present observations, they do not seem to recur till after a period of ten years or more.

A third variable star was discovered in the head on the 20th of June, 1670, by Anthelme. It appeared then to be of the 3d magnitude, but was so far diminished in the following October, as to be scarcely visible. In the beginning of April, 1671, it was again seen, and was rather brighter than at first. After several changes, it disappeared in March, 1672, and has not been observed since.

These remarkable facts seem to indicate, that there is a brilliant planetary system in this constellation, which, in some of its revolutions, becomes visible to us.

History.—Mythologists give various accounts of the origin of this constellation. Some suppose it is Orpheus, the celebrated musician, who, on being murdered by the cruel priestess of Bacchus, was changed into a Swan, and placed near his Harp in the heavens. Others suppose it is the swan into which Jupiter transformed himself when he deceived Leda, wife of Tyndarus, king of Sparta. Some affirm that it was Cycnus, a son of Neptune, who was so completely invulnerable that neither the javelins nor arrows, nor even the blows of Achilles, in furious combat, could make any impression.

" Headlong he leaps from off his lofty car,
And in close fight on foot renews the war;—
But on his flesh nor wound nor blood is seen,
The sword itself is blunted on the skin."

But when Achilles saw that his darts and blows had no effect on him, he immediately threw him on the ground and smothered him. While he was attempting to despoil him of his armor, he was suddenly changed into a swan.

" With eager haste he went to strip the dead;
The vanished body from his arms was fled.
His sea-god sire, to immortalize his fame,
Had turned it to a bird that bears his name."

According to Ovid this constellation took its name from Cycnus, a relative of Phaeton, who deeply lamented the untimely fate of that youth, and the melancholy end of his sisters, who, standing around his tomb, wept themselves into poplars.

" Cycnus beheld the nymphs transformed, allied
To their dead brother on the mortal side,
In friendship and affection nearer bound;
He left the cities, and the realms he owned,
Through pathless fields, and lonely shores to range;
And woods made thicker by the sisters' change:
While here, within the dismal gloom alone,
The melancholy monarch made his moan;
His voice was lessened as he tried to speak,
And issued through a long-extended neck:
His hair transforms to down, his fingers meet
In skinny films, and shape his oary feet;
From both his sides the wings and feathers break:
And from his mouth proceeds a blunted beak;
All Cycnus now into a swan was turned."—*Ovid's Met.* b. ii.

What variable stars have astronomers discovered in this constellation? Which of these was first discovered to be variable in 1686? In what period are its periodical changes of light completed? Describe the appearance of Sad'r. Describe the one discovered in 1670. *What do these remarkable facts indicate?*

Virgil, also, in the 10th book of his Æneid, alludes to the same fable :—

"For Cycnus loved unhappy Phaeton,
And sung his loss in poplar groves alone
Beneath the sister shades to soothe his grief;
Heaven heard his song, and hasten'd his relief;
And changed to snowy plumes his hoary hair,
And wing'd his flight to sing aloft in air."

Of all the feathered race, there is no bird, perhaps, which makes so beautiful and majestic an appearance as the swan. Almost every poet of eminence has taken notice of it. The swan has, probably, in all ages, and in every country where taste and elegance have been cultivated, been considered as the emblem of poetical dignity, purity, and ease. By the ancients it was consecrated to Apollo and the Muses; they also entertained a notion that this bird foretold its own end, and sang more sweetly at the approach of death.

———"She, like the swan
Expiring, dies in melody."—*Æschylus.*

"So on the silver stream, when death is nigh,
The mournful swan sings its own elegy."—*Ovid's* Tristia.

CAPRICORNUS.

The Goat.—This is the tenth sign, and eleventh constellation, in the order of the Zodiac, and is situated south of the Dolphin, and next east of Sagittarius. Its mean declination is 20° south, and its mean right ascension, 310°. It is therefore on the meridian about the 18th of September. It is to be observed that the first point of the *sign* Capricorn, *not the constellation*, marks the southern tropic, or winter solstice. The sun, therefore, arrives at this point of its orbit the 21st of December, but does not reach the *constellation* Capricorn until the 16th of January.

The sun, having now attained its utmost declination south, after remaining a few days apparently stationary, begins once more to retrace its progress northwardly, affording to the wintry latitudes of the north a grateful presage of returning spring.

At the period of the winter solstice, the sun is vertical to the tropic of Capricorn, and the southern hemisphere enjoys the same light and heat which the northern hemisphere enjoys on the 21st of June, when the sun is vertical to the tropic of Cancer. It is, at this period, mid-day at the south pole, and midnight at the north pole.

The whole number of stars in this constellation is fifty-one; none of which are very conspicuous. The three largest are only of the 3d magnitude. There is an equal number of the 4th.

Where is Capricornus situated? What are its mean right ascension and declination? When is the main body of the constellation on the meridian? When does the sun enter the *sign*, and when the *constellation* Capricorn? Does the sun ever extend beyond this point into the southern hemisphere? What is the position of the sun with respect to the tropic of Capricorn, at the winter solstice, and what are the seasons in the two hemispheres? What are the number and magnitude of the stars in this constellation?

The head of Capricorn may be recognized by means of two stars of the 3d magnitude, situated a little more than 2° apart, called *Giedi* and *Dabih*. They are 28° from the Dolphin, in a southerly direction.

Giedi is the most northern star of the two, and is double. If a line be drawn from Lyra through Altair, and produced about 23° farther, it will point out the head of Capricorn. These two stars come to the meridian the 9th of September, a few minutes after Sad'r, in Cygni.

A few other stars of inferior note may be traced out by reference to the maps.

The *sign* of the Goat was called by the ancient orientalists the "Southern gate of the Sun," as Cancer was denominated the "Northern gate." The ten stars in the *sign* Capricorn, known to the ancients by the name of the "Tower of Gad," are probably now in the constellation Aquarius.

History.—Capricornus is said to be Pan, or Bacchus, who, with some other deities were feasting near the banks of the Nile, when suddenly the dreadful giant Typhon came upon them, and compelled them all to assume a different shape, in order to escape his fury. Ovid relates,

"How Typhon, from the conquer'd skies, pursued
Their routed godheads to the seven-mouth'd flood:
Forced every god, (his fury to escape,)
Some beastly form to take, or earthly shape.
Jove (sings the bard) was chang'd into a ram,
From whence the horns of Libyan Ammon came;
Bacchus a goat; Apollo was a crow;
Phœbe a cat; the wife of Jove a cow,
Whose hue was whiter than the falling snow;
Mercury to a nasty ibis turned—
While Venus from a fish protection craves,
And once more plunges in her native waves."

On this occasion it is further related that Bacchus, or Pan, led the way and plunged into the Nile, and that the part of his body which was under the water assumed the form of a fish, and the other part that of a goat; and that to preserve the memory of this frolic, Jupiter made him into a constellation, in his metamorphosed shape.

Some say that this constellation was the goat Amalthea, who supported the infant Jupiter with her milk. To reward her kindness, the father of the gods placed her among the constellations, and gave one of her horns to the nymphs who had taken care of him in his infantile years. This gift was ever after called the *horn of plenty;* as it possessed the virtue of imparting to the holder whatever she desired.*

The real sense of this fable. divested of poetical embellishment, appears to be this; that in Crete, some say in Libya, there was a small territory shaped very much like a bullock's horn, and exceedingly fertile, which the king presented to his daughter Amalthea, whom the poets feigned to have been Jupiter's nurse.

"The bounteous Pan," as he is styled by Milton, was the god of rural scenery, shepherds, and huntsmen. Virgil thus addresses him:—

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* On this account the Latin term *Cornucopia*, denotes plenty, or abundance of good things. The word Amalthea, when used figuratively, has also the same meaning.

How may it be recognized? How are Giedi and Dabih situated with respect to the Dolphin? How are these two stars distinguished from each other, and what is their position in respect to the Eagle? When are they on our meridian? What were the signs Capricorn and Cancer originally called? Where are the ten stars, known to the ancients by the name of the "Tower of Gad," now to be found?

"And thou, the shepherd's tutelary god,
Leave, for a while, O Pan! thy loved abode." *

The name of Pan is derived from a Greek word signifying *all things;* and he was often considered as the great principle of vegetable and animal life. He resided chiefly in Arcadia, in woods and the most rugged mountains. As Pan usually terrified the inhabitants of the adjacent country, even when he was no where to be seen, that kind of fear which often seizes men, and which is only ideal or imaginary, has received from him the name of *Panic.*

CHAPTER XII.

DIRECTIONS FOR TRACING THE CONSTELLATIONS WHICH ARE ON THE MERIDIAN IN OCTOBER.

PEGASUS.

The Flying Horse.—This constellation is represented in an inverted posture, with wings. It occupies a large space in the heavens, between the Swan, the Dolphin and the Eagle, on the west, and the Northern Fish and Andromeda, on the east. Its mean right ascension is 340°, or it is situated 20° W. of the *prime meridian.* It extends from the equinoctial N. 35°. Its mean length E. and W. is about 40°, and it is six weeks in passing our meridian, viz. from the 1st of October to the 10th of November.

We see but a part of Pegasus, the rest of the animal being, as the poets imagined, hid in the clouds.

It is readily distinguished from all other constellations by means of four remarkable stars, about 15° apart, forming the figure of a square, called the *Square of Pegasus.* The two western stars in this square come to the meridian about the 23d of October, and are 13° apart. The northern one, which is the brightest of three triangular stars in the martingale, is of the 2d magnitude, and is called *Scheat.* Its declination is 26¾° N. *Markab,* also of the 2d magnitude, situated in the head of the wing, is 13° S. of Scheat, and passes the meridian 11 minutes after it.

* Pales, the female deity corresponding to Pan, was the goddess of sheepfolds and of pastures among the Romans. Thus Virgil:—

"Now, sacred Pales, in a lofty strain,
I sing the rural honors of thy reign."

The shepherds offered to this goddess milk and honey, to gain her protection over their flocks. She is represented as an old woman, and was worshiped with great solemnity at Rome. Her festivals which were called *Palilia,* were celebrated on the 20th of April, the day on which Romulus laid the foundations of the city.

How is Pegasus represented? What space and position does it occupy in the heavens? What are the distance and direction of its center from the prime meridian? What are its mean length and breadth? How long is it in passing our meridian? When does it pass the meridian? How is this constellation distinguished from all others? Describe the two stars which form the west side of the square.

The two stars which form the eastern side of the square, come to the meridian about an hour after those in the western. The northern one has already been described as *Alpheratz* in the head of Andromeda, but it also belongs to this constellation, and is 14° E. of Scheat. 14° S. of Alpheratz, is *Algenib*, the last star in the wing, situated 16½° E. of Markab.

Algenib in *Pegasus*, *Alpheratz* in Andromeda, and *Caph* in Cassiopeia are situated on the *prime meridian*, and point out its direction through the pole. For this reason, they are sometimes called the *three guides*. They form an arc of that great circle in the heavens from which the distances of all the heavenly bodies are measured. It is an arc of the equinoctial colure which passes through the vernal equinox, and which the sun crosses about the 21st of March. It is, in astronomy, what the meridian of Greenwich is in geography. If the sun, or a planet, or a star, be said to have so many degrees of right ascension, it means that the sun or planet has *ascended* so many degrees from this prime meridian

Enif, sometimes called *Enir*, is a star of the 3d magnitude in the nose of Pegasus, about 20° W. S. W. of Markab. and half-way between it and the Dolphin. About half of the distance from Markab toward Enif, but a little to the S., there is a star of the 3d magnitude situated in the neck, whose *letter* name is *Zeta*. The loose cluster directly S. of the line joining Enif and Zeta, forms the head of Pegasus.

In this constellation there are eighty-nine stars visible to the naked eye, of which three are of the second magnitude and three of the third.

HISTORY.—This, according to fable, is the celebrated horse which sprung from the blood of Medusa, after Perseus had cut off her head. He received his name according to Hesiod, from his being born near the sources (πηγη, Pege) of the ocean. According to Ovid, he fixed his residence on Mount Helicon, where by striking the earth with his foot, he raised the fabled fountain called Hippocrene. He became the favorite of the Muses; and being tamed by Neptune or Minerva, he was given to Bellerophon, son of Glaucus, king of Ephyre, to aid him in conquering the Chimæra, a hideous monster that continually vomited flames. This monster had three heads, that of a lion, a goat, and a dragon. The fore parts of its body were those of a lion, the middle those of a goat, and the hinder those of the dragon. It lived in Lycia, of which the top, on account of its desolate wilderness, was the resort of lions, the middle, which was fruitful, was covered with goats. and at the bottom, the marshy ground abounded with serpents. Bellerophon was the first who made his habitation upon it.

Plutarch thinks the Chimæra was the captain of some pirates who adorned their ship with the images of a lion, a goat, and a dragon.

After the destruction of this monster, Bellerophon attempted to fly up to heaven upon Pegasus; but Jupiter was so displeased at this presumption, that he sent an insect to sting the horse, which occasioned the melancholy fall of his rider. Bellerophon fell to the earth. and Pegasus continued his flight up to heaven, and was placed by Jupiter among the constellations.

"Now heav'n his further wand'ring flight confines,
Where, splendid with his num'rous stars, he shines.
Ovid's Fasti.

EQUULUS, VEL EQUI SECTIO.

THE LITTLE HORSE, OR THE HORSE'S HEAD.—This Asterism, or small cluster of stars, is situated about 7° W. of Enif, in the head of Pegasus, and about half-way between it

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Describe the two on the east side. What is the name of the star in the N. E. corner of the square? In the S. E. corner? In the S. W. corner? In the N. W. corner? *Describe the position and magnitude of Enif.* What is the whole number of stars in Pegasus? What is the magnitude of the principal ones? Describe the situation of the Little Horse.

and the Dolphin. It is on the meridian at 8 o'clock, on the 11th of October. It contains ten stars, of which the four principal are only of the 4th magnitude. These may be readily distinguished by means of the long irregular square which they form. The two in the nose are much nearer together than the two in the eyes; the former being 1° apart, and the latter 2½°. Those in the nose are uppermost, being 4° N. of those in the eyes. This figure also is in an *inverted* position. These four stars are situated 10° or 12° S. E. of the diamond in the Dolphin's head. Both of these clusters are noticeable on account of their figure rather than their brilliancy.

HISTORY.—This constellation is supposed to be the brother of Pegasus, named *Celeris*, given by Mercury to Castor, who was so celebrated for his skill in the management of horses; others take him to be the celebrated horse which Neptune struck out of the earth with his trident, when he disputed with Minerva for superiority. The head only of Celeris is visible, and this, also, is represented in an inverted position.

AQUARIUS.

THE WATER-BEARER.—This constellation is represented by the figure of a man, pouring out water from an urn. It is situated in the Zodiac, immediately S. of the equinoctial, and bounded by the Little Horse, Pegasus, and the Western Fish on the N., the Whale on the E., the Southern Fish on the S. and the Goat on the W. It is now the 12th in order, or last of the Zodiacal constellations; and is the name of the 11th *sign* in the ecliptic. Its mean declination is 14° S., and its mean right ascension 335°, or 22 hours, 20 min.; it being 1 hour and 40 min. W. of the equinoctial colure; its center is, therefore, on the meridian the 15th of October.

It contains one hundred and eight stars; of which the four largest are all of the 3d magnitude.

> "His head, his shoulders, and his lucid breast,
> Glisten with stars; and where his urn inclines,
> Rivers of light brighten the watery track."

The north-eastern limit of Aquarius may be readily distinguished by means of four stars of the 4th magnitude, in the hand and handle of the urn, so placed as to form the letter Y, very plainly to be seen, 15° S. E. of *Enif*, or 18° S. S. W. of Markab, in Pegasus; making with the two latter nearly a right angle.

When is it on the meridian? What is the whole number of its stars? What is the magnitude of the principal ones? How may the principal stars be distinguished? How are the two in the nose distinguished from the two in the eyes? What are their distance and direction from the Dolphin? On what account are these clusters noticeable? How is Aquarius represented? Where is it situated? What is its present order among the constellations of the Zodiac? What are its right ascension and declination? What is the whole number of its stars? What is the magnitude of the principal ones? How may the N. E. limit of Aquarius be readily distinguished? What are the distance and direction of this letter Y from Markab and Enif, in Pegasus?

About 4½° W. of this figure is *El Melik*, a star of the 3d magnitude, in the E. shoulder, and the principal one in this constellation. 10° S. W. of El Melik, is another star of the same magnitude, situated in the W. shoulder, called *Sad es Saud.*

Ancha, of the 4th magnitude, is in the right side, 8° S. of El Melik. 9° E. of Ancha, is another star of the 4th magnitude, whose letter name is *Lambda.*

Scheat, of the 3d magnitude, lying below the knee, is situated 8½° S. of Lambda; and 14° S. of Scheat, the brilliant star Fomalhaut,* of between the 1st and 2d magnitudes, terminates the cascade in the mouth of the Southern Fish. This star is common to both these constellations, and is one of those from which the lunar distance is computed for ascertaining the longitude at sea. It culminates at 9 o'clock on the 22d of October.

Fomalhaut,* Deneb Kaitos, and Alpha in the head of the Phœnix, make a large triangle, whose vertex is in Deneb Kaitos. Those two stars of the 4th magnitude, situated 4° S. of Sad es Saud, and nearly the same distance from Ancha, are in the tail of Capricorn. They are about 2° apart. The western one is called *Deneb Algedi.*

The rest of the stars in the cascade are quite small; they may be traced from the letter Y, in the urn, in a south-easterly direction toward the tail of Cetus, from which the cascade suddenly bends off near Scheat, in an opposite course, and finally disappears in the mouth of the Southern Fish, 30° S. of Y.

HISTORY.—This constellation is the famous Ganymede, a beautiful youth of Phrygia, son of Tros, king of Troy, or, according to Lucian, son of Dardanus. He was taken up to heaven by Jupiter as he was tending his father's flocks on Mount Ida, and became the cup-bearer of the gods in place of Hebe. There are various opinions, however, among the ancients respecting its origin. Some suppose it represents Deucalion, who was placed among the stars after the celebrated deluge of Thessaly, 1500 years before the birth of our Saviour; while others think it designed to commemorate Cecrops, who came from Egypt to Greece, founded Athens, established science, and introduced the arts of polished life.

The ancient Egyptians supposed the setting or disappearance of Aquarius caused the Nile to rise, by the sinking of his urn in the water.—In the Zodiac of the Hebrews, Aquarius represents the tribe of Reuben.

PISCES AUSTRALIS, VEL NOTIUS.

THE SOUTHERN FISH.—This constellation is directly S. of Aquarius, and is represented as a fish drinking the water which Aquarius pours from his urn. Its mean declination is 31° S. and its mean right ascension and time of passing the meridian are the same as those of Aquarius, and it is seen on the meridian at the same time, viz. on the 15th of October. It contains 24 visible stars, of which one is of the 1st magnitude, or between the 1st and 2d, two are of the 3d, and five of the 4th. The first and most beautiful of all is *Fomalhaut*, situated in the mouth. This is 14° directly S. of Scheat in Aquarius, and may be seen passing the meridian low down in the southern hemisphere, on the 22d and 23d of October.

* Pronounced *Fo-ma-lo.*

What is the name of the principal star in this constellation? *What is its position? What star in the W. shoulder? Describe the situation of Ancha. What is the position of Scheat and Fomalhaut? To what constellations is Fomalhaut common? Of what nautical importance is it? When does it culminate? With what other stars does it form a large triangle? How may you trace the stars in the cascade?* Describe the situation and appearance of the Southern Fish. What are its mean right ascension and declination? When is it on the meridian? What is the whole number of its stars? What is the magnitude of its principal ones? What are the name and position of the most brilliant star in the constellation? When and where does it pass the meridian?

Its position in the heavens has been determined with the greatest possible accuracy, to enable navigators to find their longitude at sea.

The mode of doing this cannot be explained here. The problem is one of some difficulty. It consists in finding the angular distance between some star whose position is well known, and the moon when she is passing near it; also, the altitude of each, at the same instant, with good sextants. These data furnish the elements of a spherical triangle, the solution of which, after various intricate corrections, is made to result in the longitude of the given place.—*See note to Arietes.* In 1714, the British Parliament offered a reward of 10.000 pounds sterling, to any man who should discover a method of determining the longitude within 1°, or 60 geographic miles of the truth; 15,000 pounds to the man who should find it within 40 miles, and 20,000 pounds, if found within 30 miles. These rewards in part have been since distributed among eminent mathematicians, in Europe, agreeably to the respective merits of their discoveries.

HISTORY.—This constellation is supposed to have taken its name from the transformation of Venus into the shape of a fish, when she fled, terrified at the horrible advances of the monster Typhon, as we have related in the mythology of the Fishes.—(*See Pisces.*)

CHAPTER XIII.

VARIABLE AND DOUBLE STARS—CLUSTERS—NEBULÆ.

1. VARIABLE STARS.—The periodical variations of brilliancy to which some of the fixed stars are subject, may be reckoned among the most remarkable of their phenomena. Several stars, formerly distinguished by their splendor, have entirely disappeared; others are now conspicuous which do not seem to have been visible to the ancient observers; and there are some which alternately appear and disappear, or, at least, of which the light undergoes great periodic changes. Some seem to become gradually more obscure, as *Delta* in the Great Bear; others, like *Beta* in the Whale, to be increasing in brilliancy. Some stars have all at once blazed forth with great splendor, and, after a gradual diminution of their light, again become extinct. The most remarkable instance of this kind is that of the star which appeared in 1572, in the time of Tycho Brahe. It suddenly shone forth, in the constellation Cassiopeia, with a splendor exceeding that of stars of the first magnitude, even of Jupiter and of Venus, at their least distances from the earth; and could be seen, with the naked eye, on the meridian, in full day! Its brilliancy gradually diminished from the time of its first appearance, and at the end of sixteen months, it entirely disap-

For what purpose has its position been very accurately determined? Describe the periodical variations of brilliancy to which some of the fixed stars are subject? Mention some of the most remarkable instances of such variations, and describe them particularly.

peared, and has never been seen since. *(See a more particular account of this phenomenon, page 40.)*

Another instance of the same kind was observed in 1604, when a star of the first magnitude suddenly appeared in the right foot of Ophiuchus. It presented, like the former, all the phenomena of a prodigious flame, being, at first, of a dazzling white, then of a reddish yellow, and, lastly, of a leaden paleness; in which its light expired. These instances prove that the stars are subject to great physical revolutions.—*Page* 41.

A great number of stars have been observed whose light seems to undergo a regular periodic increase and diminution. They are properly called *Variable Stars.* One in the *Whale* has a period of 334 days, and is remarkable for the *magnitude* of its variations. From being a star of the second magnitude, it becomes so dim as to be seen with difficulty through powerful telescopes. Some are remarkable for the *shortness of the period* of their variation. *Algol* has a period of between two and three days; *Delta Cephei*, of 5⅓ days; *Beta Lyræ*, of 6 2-5 days; and *Mu Antinoi*, of 7 days.

The regular succession of these variations precludes the supposition of an actual destruction of the stars; neither can the variations be supposed to arise from a change of distance; for as the stars invariably retain their apparent places, it would be necessary to suppose that they approach to, and recede from the earth in *straight lines*, which is very improbable. The most probable supposition is, that the stars revolve, like the sun and planets, about an axis. "Such a motion," says the elder Herschel, "may be as evidently proved, as the diurnal motion of the earth. Dark spots, or large portions of the surface, less luminous than the rest, turned alternately in certain directions, either toward or from us, will account for all the phenomena of periodical changes in the luster of the stars, so satisfactorily, that we certainly need not look for any other cause."

2. Double Stars.—On examining the stars with telescopes of considerable power, many of them are found to be composed of two or more stars, placed contiguous to each other, or of which the distance subtends a very minute angle. This appearance is, probably, in many cases, owing solely to the optical effect of their position relative to the spectator; for it is evident that two stars will appear contiguous if they

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What are such stars denominated? Describe the variations of one in the Whale. What stars are remarkable for the shortness of the period of their variations? Why may we not suppose that the stars which disappear are actually destroyed? Why may not the variations arise from a change of distance? What is the most probable supposition in regard to their cause? How does Dr. Herschel explain these phenomena? On examining the stars with a telescope of considerable power, what other peculiarity do we find? To what is this appearance, in many cases, owing?

are placed nearly in the same line of vision, although their real distance may be immeasurably great.

There are, however, many instances in which the angle of position of the two stars varies in such a manner as to indicate a revolution about each other and about a *common center*. In this case they are said to form a *Binary System* performing to each other the office of sun and planet, and are connected together by laws of gravitation like those which prevail in the solar system. The recent observations of Sir John Herschel and Sir James South, have established the truth of this singular fact, beyond a doubt. Motions have been detected, so rapid as to become measurable within very short periods of time; and at certain epochs, the satellite or feebler star has been observed to disappear, either passing behind or before the primary, or approaching so near to it that its light has been absorbed by that of the other.

The most remarkable instance of a regular revolution of this sort, is that of *Mizar*, in the tail of the Great Bear; in which the angular motion is 6 degrees and 24 minutes of a great circle, annually; so that the two stars complete a revolution about one another in the space of 58¼ years. About eleven twelfths of a complete circuit have been already described since its discovery in 1781, the same year in which the planet Herschel was discovered.

A double star in Ophiuchus presents a similar phenomenon, and the satellite has a motion in its orbit still more rapid. *Castor* in the Twins,* *Gamma Virginis*, *Zeta* in the Crab, *Zi Bootis*, *Delta Serpentis*, and that remarkable double star 61 *Cygni*, together with several others, amounting to 40 in number,† exhibit the same evidence of a revolution about each other and about a common center. But it is to be remembered that these are not the revolutions of bodies of a planetary nature around a solar center, but of sun around sun—each, perhaps, accompanied by its train of planets, and *their* satellites, closely shrouded from our view by the splendor of their respective suns, and crowded into a space bearing hardly a greater proportion to the enormous interval which separates *them*, than the distances of the satellites of our

* Page 67. † Herschel's Astronomy, page 391.

Are there, however, any instances where one star revolves with another around a common center? When two stars are thus situated, what system are they said to form? Why is it thus denominated? What modern astronomers of great celebrity have established the truth of this theory? What rates of motion did they detect in these binary systems? What other interesting phenomena, indicating a mutual revolution, did they discover? What is the most remarkable instance of this fact? Mention some other instances. Are these revolving stars of a planetary nature? Of what nature are they?

planets from their primaries, bear to their distances from the sun itself.

The examination of double stars was first undertaken by the late Sir William Herschel, with a view to the question of parallax. His attention was, however, soon arrested by the new and unexpected phenomena which these bodies presented. Sir William observed of them, in all, 2400. Sir James South and Herschel have given a catalogue of 380 in the Transactions of the Royal Society for 1824, and South added 458 in 1826. Sir John Herschel, in addition to the above, published an account of 1000, before he left England for the Cape of Good Hope, where he is, at the time we write, pushing his discoveries in the southern hemisphere with great perseverance and success. Professor Struve, with the great Dorpat telescope, has given a catalogue of 3.063 of the most remarkable of these stars.

The object of these catalogues is not merely to fix the place of the star within such limits as will enable us easily to discover it at any future time, but also to record a description of the appearance, position, and mutual distances of the individual stars composing the system, in order that subsequent observers may have the means of detecting their connected motions, or any changes which they may exhibit. Professor Struve has also taken notice of 52 triple stars, among which No. 11 of the *Unicorn*, *Zeta* of Cancer, and *Zi* of the Balance, appear to be *ternary systems* in motion. Quadruple and quintuple stars have likewise been observed, which also appear to revolve about a common center of gravity; in short, every region of the heavens furnishes examples of these curious phenomena.

Color of the Stars.—Many of the double stars exhibit the curious and beautiful phenomenon of *contrasted colors*, or *complimentary tints*. In such instances, the larger star is usually of a ruddy or orange hue, while the smaller one appears blue or green, probably in virtue of that general law of optics, which provides, that when the retina is under the influence of excitement by any bright, colored light, feebler lights, which seen alone would produce no sensation but that of whiteness, shall for the time appear colored with the tint complimentary to that of the brighter. Thus, a yellow color predominating in the light of the brighter star, that of the less bright one, in the same field of view, will appear blue; while, if the tint of the brighter star verge to crimson, that of the other will exhibit a tendency to green—or even appear a vivid green. The former contrast is beautifully exhibited by *Iota*, in Cancer; the latter by *Almaack*, in Andromeda—both fine double stars. If, however, the colored star be much the less bright of the two, it will not materially affect the other. Thus, for instance, *Eta* Cassiopeiæ exhibits the beautiful combination of a large white star, and a small one of a rich ruddy purple.

It is not easy to conceive what variety of illumination *two suns*—a red and a green, or a yellow and a blue one—must afford to a planet revolving about either; and what charming

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What beautiful and curious phenomenon has been observed, as it regards the color of double stars? Explain how these colors are usually contrasted. Mention an example of this phenomenon. How, if the colored star be much the less bright of the two, will the other be affected? Give an instance. What may be the *effect* of such a variety of color in solar light?

contrasts and grateful vicissitudes—a *red* and a *green* day, for instance, alternating with a *white* one and with *darkness* —might arise from the presence or absence of one or the other, or both, above the horizon. Insulated stars of a red color, almost as deep as that of blood, occur in many parts of the heavens, but no green or blue star (of any decided hue) has, we believe, ever been noticed, unassociated with a companion brighter than itself.

3. Clusters.—When we cast our eyes over the concave surface of the heavens in a clear night, we do not fail to observe that there are, here and there, groups of stars which seem to be compressed together more densely than those in the neighboring parts; forming bright patches and clusters.

There is a group called the *Pleiades*, in which six or seven stars may be noticed, if the eye be directed full upon it; and many more if *the eye* be turned carelessly aside, while the *attention* is kept directed* upon the group. Telescopes show fifty or sixty large stars thus crowded together in a very moderate space, and comparatively insulated from the rest of the heavens. Rheita affirms that he counted 200 stars in this small cluster. The constellation, called Coma Berenices, is another group, more diffused, and consisting of much larger stars.

In the constellation Cancer, there is a nebulous cluster of very minute stars, called *Præsepe*, or the Beehive, which is sufficiently luminous to be seen by the naked eye, in the absence of the moon, and which any ordinary spyglass will resolve into separate stars. In the sword-handle of Perseus, also, is another such spot, crowded with stars. It requires, however, rather a better telescope to resolve it into individual stars.

These are called *Clusters of Stars*. Whatever be their nature, it is certain that other laws of aggregation subsist in these spots, than those which have determined the scattering of stars over the general surface of the sky. Many of them, indeed, are of an exactly round figure, and convey the idea of a globular space filled full of stars, and constituting, in itself, a family or society apart, and subject only to its own internal laws.

"It would be a vain task," says the younger Herschel, "to

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* "It is a very remarkable fact," says Sir John Herschel, "that the *center* of the visual organ is by far less sensible to feeble impressions of light, than the exterior portions of the retina."—*Ast. p.* 398.

Are individual stars of a deep color ever found separate from others? What are clusters of stars? Mention some instance. Describe it. Mention some other instance. Describe the position and appearance of *Præsepe*. Describe any other cluster which you may recollect. What are the constitution and figure of such groups? What did the younger Herschel say of the number of stars which compose these clusters?

attempt to count the stars in one of these globular clusters. They are not to be reckoned by hundreds; for it would appear that many clusters of this description must contain, at least, ten or twenty thousand stars, compacted and wedged together in a round space, not more than a tenth part as large as that which is covered by the moon.

4. Nebulæ.--The Nebulæ, so called from their dim, cloudy appearance, form another class of objects which furnish matter for curious speculation and conjecture respecting the formation and structure of the sidereal heavens. When examined with a telescope of moderate powers, the greater part of the nebulæ are distinctly perceived to be composed of little stars, imperceptible to the naked eye, because, on account of their apparent proximity, the rays of light proceeding from each are blended together, in such a manner as to produce only a confused luminous appearance.

In other nebulæ, however, no individual stars can be perceived, even through the best telescopes; and the nebulæ exhibit only the appearance of a self-luminous phosphorescent patch of gaseous vapor, though it is possible that even in this case, the appearance may be owing to a congeries of stars so minute, or so distant, as not to afford, singly, sufficient light to make an impression on the eye.

In some instances a nebula presents the appearance of a faint luminous atmosphere, of a circular form, and of large extent, surrounding a central star of considerable brilliancy.

One of the most remarkable nebulæ is in the sword-handle of Orion. It is formed of little flocky masses, like wisps of cloud, which seem to adhere to many small stars at its outskirts. It is not very unlike the mottling of the sun's disc, but of a coarser grain, and with darker intervals. These wisps of light, however, present no appearance of being composed of small stars; but in the intervals between them, we fancy that we see stars, or that, could we strain our sight a little more, we should see them. These intervals may be compared to openings in the firmament, through which, as through a window, we seem to get a glimpse of other heavens, and brighter regions beyond.—*Page* 58.

Another very remarkable nebula is that in the girdle of Andromeda, which, on account of its being visible to the naked eye, has been known since the earliest ages of astronomy. It is often mistaken for a comet, by those unacquainted

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Why are the nebulæ so called? Describe the usual appearances of nebulæ, as seen through a telescope. What other appearance do nebulæ sometimes exhibit? Mention some instances of the most remarkable nebulæ. Describe the one in the sword-handle of Orion. Describe the one which is in the girdle of Andromeda.

with the heavens. Marius, who noticed it in 1612, describes its appearance as that of a candle shining through horn; and the resemblance is certainly very striking. Its form is a long oval, increasing, by insensible gradations of brightness, from the circumference to a central point, which, though very much brighter than the rest, is not a star, but only a nebula in a high state of condensation. No power of vision hitherto directed to this nebula has been able to resolve it into the least appearance of stars. It occupies an area comparatively large —equal to that of the moon in quadrature. This nebula may be considered as a type, on a large scale, of a very numerous class of nebulæ, of a round or oval figure, increasing more or less in density toward the center.

Annular nebulæ also exist, but are among the rarest objects in the heavens. The most conspicuous of this class, is to be found exactly half-way between the stars *Beta* and *Gamma* Lyræ, and may be seen with a telescope of moderate power. It is small, and particularly well defined; appearing like a flat oval ring. The central opening is not entirely dark, but is filled with a faint, hazy light, uniformly spread over it, like a fine gauze stretched over a hoop.

Planetary nebulæ are very extraordinary objects. They have, as their name imports, the appearance of planets, with round or slightly oval discs, somewhat mottled, but approaching, in some instances, to the vividness of actual planets. Some of them, upon the supposition that they are equally distant from us with the stars, must be of enormous magnitude. That one, for instance, which is situated in the left hand of Aquarius, must have a volume vast enough, upon the lowest computation, to fill the whole orbit of Herschel!

The nebulæ furnish an inexhaustible field of speculation and conjecture. That by far the larger number of them consists of stars, there can be little doubt; and in the interminable range of system upon system, and firmament upon firmament, which we thus catch a glimpse of, the imagination is bewildered and lost. Sir William Herschel conjectured that the nebulæ might form the materials out of which nature elaborated new suns and systems, or replenished the wasted light of older ones. But the little we know of the physical constitution of these sidereal masses, is altogether insufficient to warrant such a conclusion.

Of what class of nebulæ may this be considered as a type? What other species of nebulæ exist in the heavens? Describe the most conspicuous of this class. What other species of nebulæ are more rarely found? Describe the appearance of planetary nebulæ. What do we know in regard to their magnitude? How large must the one be which is situated in the left hand of Aquarius? What did Sir William Herschel conjecture as to the use of the nebulæ? Have we facts sufficient to warrant such a conjecture?

CHAPTER XIV.

VIA LACTEA.

"Throughout the Galaxy's extended line,
Unnumber'd orbs in gay confusion shine:
Where every star that gilds the gloom of night
With the faint tremblings of a distant light,
Perhaps illumes some system of its own,
With the strong influence of a radiant sun."—*Mrs. Carter.*

THERE is a luminous zone or pathway of singular whiteness, varying from 4° to 20° in width, which passes quite round the heavens. The Greeks called it GALAXY, on account of its color and appearance: the Latins, for the same reason, called it VIA LACTEA, which, in our tongue, is *Milky Way.*

Of all the constellations which the heavens exhibit to our view, this fills the mind with the most indescribable grandeur and amazement. When we consider what unnumbered millions of mighty suns compose this cluster, whose distance is so vast that the strongest telescope can hardly separate their mingled twilight into distinct specks, and that the most contiguous of any two of them may be as far asunder as our sun is from them, we fall as far short of adequate language to express our ideas of such immensity, as we do of instruments to measure its boundaries.

It is one of the recent achievements of astronomy that has resolved the Milky-Way into an infinite number of small stars, whose confused and feeble luster occasions that peculiar whiteness which we see in a clear evening, when the moon is absent. It is also a recent and well-accredited doctrine of astronomy, that all the stars in the universe are arranged into clusters, or groups, which are called NEBULÆ or STARRY SYSTEMS, each of which consists of many thousands of stars

The fixed star which we call OUR SUN, belongs, it is said, to that extensive nebula, the Milky-Way; and although apparently at such an immeasurable distance from its fellows, is, doubtless, as near to any one of them, as they are to one another.

Of the number and economy of the stars which compose this group, we have very little exact knowledge. Dr. Herschel informs us that, with his best glasses, he saw and

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What do you understand by the Milky-Way? By what different names is it called? Why does the contemplation of this constellation fill the mind with ideas of grandeur and amazement? What causes the whiteness of the Milky-Way? Into what are all the stars in the universe arranged? To what nebulæ does the sun belong, and what is probably its distance from its fellows? What knowledge have we of the number and economy of the stars in this group?

counted 588 stars in a single spot, without moving his telescope; and as the gradual motion of the earth carried these out of view and introduced others successively in their places, while he kept his telescope steadily fixed to one point, "there passed over his field of vision, in the space of one quarter of an hour, no less than *one hundred and sixteen thousand stars*, and at another time, in forty-one minutes, no less than *two hundred and fifty-eight thousand*."

In all parts of the Milky-Way he found the stars unequally dispersed, and appearing to arrange themselves into separate clusters. In the small space, for example, between Beta and Sad'r, in Cygni, the stars seem to be clustering in two divisions; each division containing upwards of one hundred and sixty-five thousand stars.

At other observations, when examining a section of the Milky-Way, not apparently more than a yard in breadth, and six in length, he discovered *fifty thousand* stars, large enough to be distinctly counted; and he suspected twice as many more, which, for want of sufficient light in his telescope, he saw only now and then.

It appears from numerous observations, that various changes are taking place among the nebulæ—that several nebulæ are formed by the dissolution of larger ones, and that many nebulæ of this kind are at present detaching themselves from the Milky-Way. In hat part of it which is in the body of Scorpio, there is a large opening, about 4° broad, almost destitute of stars. These changes seem to indicate that mighty movements and vast operations are continually going on in the distant regions of the universe, upon a scale of magnitude and grandeur which baffles the human understanding.

More than two thousand five hundred nebulæ have already been observed; and, if each of them contains as many stars as the Milky-Way, several hundreds of millions of stars must exist, even within that portion of the heavens which lies open to our observation.

> "O what a confluence of ethereal fires.
> From urns unnumber'd down the steep of heaven
> Streams to a point, and centers on my sight."

Although the Milky-Way is more or less visible at all seasons of the year, yet it is seen to the best advantage during the months of July, August, September, and October. When Lyra is on, or near the meridian, it may be seen

How many did Dr. Herschel count in a single spot during the space of 15 minutes? How did he find the stars dispersed, throughout the Milky-Way? Give an example. Give another instance. What changes are taking place in the Milky-Way and other nebulæ? What do these changes indicate? How many nebulæ have been discovered? If each of these nebulæ contains as many stars as the Milky-Way, how many stars must exist even in that portion of the heavens which lies open to our observation? Where and at what period may the Milky-Way be seen to the best advantage?

stretching obliquely over the heavens from north-east to south-west, gradually moving over the firmament in common with other constellations.

Its form, breadth and appearance are various, in different parts of its course. In some places it is dense and luminous; in others, it is scattered and faint. Its breadth is often not more than five degrees; though sometimes it is ten or fifteen degrees, and even twenty. In some places it assumes a double path, but for the most part it is single.

It may be traced in the heavens, beginning near the head of Cepheus, about 30° from the north pole, through the constellations Cassiopeia, Perseus, Auriga, and part of Orion and the feet of Gemini, where it crosses the Zodiac; thence over the equinoctial into the southern hemisphere, through Monoceros, and the middle of the ship Argo, where it is most luminous, Charles' Oak, the Cross, the feet of the Centaur, and the Altar. Here it is divided into two branches, as it passes over the Zodiac again into the northern hemisphere. One branch runs through the tail of Scorpio, the bow of Sagittarius, the shield of Sobieski, the feet of Antinous, Aquila, Delphinus, the Arrow, and the Swan. The other branch passes through the upper part of the tail of Scorpio, the side of Serpentarius, Taurus Poniatowski, the Goose and the neck of the Swan, where it again unites with the other branch, and passes on to the head of Cepheus, the place of its beginning.

There are several other nebulæ in the heavens as large as the Milky-Way, but not visible to the naked eye, which may exhibit the phenomenon of a lucid zone to the planetary worlds that may be placed within them.

Some of the pagan philosophers maintained that the Milky-Way was formerly the sun's path, and that its present luminous appearance is the track which its scattered beams left visible in the heavens.

The ancient poets and even philosophers, speak of the Galaxy, or Milky-Way, as the path which their deities used in the heavens, and which led directly to the throne of Jupiter. Thus, Ovid, in his Metamorphoses, Book i. :—

> " A way there is in heaven's extended plain,
> Which when the skies are clear is seen below,
> And mortals, by the name of Milky, know;
> The groundwork is of stars, through which the road
> Lies open to the Thunderer's abode."

Milton alludes to this, in the following lines :—

> " A broad and ample road, whose dust is gold,
> And pavement, stars, as stars to thee appear,
> Seen in the Galaxy, that Milky-Way,
> Which nightly as a circling zone, thou seest
> Powdered with stars."

CHAPTER XV.

ORIGIN OF THE CONSTELLATIONS.

THE science of astronomy was cultivated by the immediate descendants of Adam. JOSEPHUS informs us that the sons

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Describe the breadth and appearance of the Milky-Way. *How may it be traced in the heavens?* Are there other nebulæ in the heavens as large as the Milky-Way? How early was the science of astronomy cultivated? What authority have we for affixing so early a date to the science?

of SETH employed themselves in the study of astronomy; and that they wrote their observations upon two pillars, one of brick, and the other of stone,* in order to preserve them against the destruction which ADAM had foretold should come upon the earth. He also relates, that Abraham argued the unity and power of God, from the orderly course of things both at sea and land, in their times and seasons, and from his observations upon the motions and influences of the sun, moon, and stars; and that he read lectures in astronomy and arithmetic to the Egyptians, of which they understood nothing till Abraham brought these sciences from Chaldea to Egypt; from whence they passed to the Greeks.

BEROSUS also observes that Abraham was a great and just man, and famous for his celestial observations; the making of which was thought to be so necessary to the human welfare, that he assigns it as the principal reason of the Almighty's prolonging the life of man. This ancient historian tells us, in his account of the longevity of the antediluvians, that Providence found it necessary to prolong man's days, in order to promote the study and advancement of virtue, and the improvement of geometry and astronomy, which required, at least, six hundred years for making and perfecting observations.†

When Alexander took Babylon, Calisthenes found that the most ancient observations existing on record in that city, were made by the Chaldeans about 1903 years before that period, which carries us back to the time of the dispersion of mankind by the confusion of tongues. It was 1500 years after this that the Babylonians sent to Hezekiah, to inquire about the shadow's going back on the dial of Ahaz.

It is therefore very probable that the Chaldeans and Egyptians were the original inventors of astronomy; but at what period of the world they marked out the heavens into constellations, remains in uncertainty. La Place fixes the date thirteen or fourteen hundred years before the Christian era, since it was about this period, that Eudoxus constructed the first celestial sphere upon which the constellations were de-

* Josephus affirms, that "he saw himself that of stone to remain in Syria in his own time."

† Vince's Complete System of Astronomy, Vol. ii. p. 244.

What does Josephus relate concerning Abraham's knowledge of astronomy? Who, does he say, first introduced this science into Egypt? What other historian of remote antiquity speaks of Abraham's attention to this science? What reason does Berosus assign for the longevity of the antediluvians? When Alexander took Babylon, what ancient observations did he find in that city? To what period of the world do these observations carry us back? How long after this was it that the Babylonians sent to Hezekiah, to inquire about the shadow's going back on the dial of Ahaz? Who, then, may we conclude, were the original inventors of astronomy, and at what period did they arrange the fixed stars into constellations? When does La Place fix the date?

lineated.* Sir Isaac Newton was of opinion, that all the old constellations related to the Argonautic expedition, and that they were invented to commemorate the heroes and events of that memorable enterprise. It should be remarked, however, that while none of the ancient constellations refer to transactions of a later date, yet we have various accounts of them, of a much higher antiquity than that event.

Some of the most learned antiquarians of Europe have searched every page of heathen mythology, and ransacked all the legends of poetry and fable for the purpose of rescuing this subject from that impermeable mist which rests upon it, and they have only been able to assure us, in general terms, that they are Chaldean or Egyptian hieroglyphics, intended to perpetuate, by means of an imperishable record, the memory of the times in which their inventors lived, their religion and manners, their achievements in the arts, and whatever in their history was most worthy of being commemorated. There was, at least, a moral grandeur in this idea; for an event thus registered, a custom thus canonized, or thus enrolled among the stars, must needs survive all other traditions of men, and stand forth in perpetual characters to the end of time.

In arranging the constellations of the Zodiac, for instance, it would be natural for them, we may imagine, to represent those stars which rose with the sun in the spring of the year, by such animals as the shepherds held in the greatest esteem at that season; accordingly, we find Aries, Taurus, and Gemini, as the symbols of March, April, and May.

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* The usual size of artificial globes, designed to represent the celestial sphere, is from 9 to 18 inches in diameter. Globes have been recently constructed in Germany, which are said to be more splendid and complete than any in the world. The *largest ever made* are that of Gottorp, two in the library of the late king of France, and one in Pembroke college, Cambridge.

The globe of Gottorp, now in the Academy of Sciences at Petersburg, is a large hollow sphere, eleven and a half feet in diameter, containing a table and seats for twelve persons. The inside represents the visible surface of the heavens, bespangled with gilded stars, ranged in their proper order and magnitude, and by means of a curious piece of mechanism by which it is put in motion, exhibits the true position of the stars, at any time, together with their rising and setting. The convex surface, or outside of this globe, represents the terrestrial sphere.

In 1704, two globes of equal dimensions, it is said, were made for Cardinal d'Estrees, by Cornelli, a Venitian, and deposited in the king's library at Paris. These, however, are far inferior in size to one of similar construction, erected at Pembroke college, in the University of Cambridge, by the late Dr. Long, president of that institution. This is a hollow sphere, sufficiently capacious to admit thirty persons to sit within it, where they can observe the artificial world of stars and planets, revolving over their heads, in the same order as they are seen in the heavens. This sphere is eighteen feet in diameter.

What opinion has Sir Isaac Newton advanced upon this subject? Have we, however, any accounts of the constellations, of a higher antiquity than that event? Do any of the ancient constellations refer to transactions of a later date? What have the most learned antiquarians of Europe done upon this subject, and of what do they assure us? How long would the memory of an action, or event, thus registered, be likely to endure? In arranging the constellations of the Zodiac, how was it natural to represent the stars?

When the sun enters the sign Cancer, at the summer solstice, he discontinues his progress toward the north pole, and begins to return toward the south pole. This retrograde motion was fitly represented by a Crab, which is said to go backward. The sun enters this sign about the 22d of June.

The heat which usually follows in the next month was represented by the Lion; an animal remarkable for its fierceness, and which at this season was frequently impelled by thirst to leave the sandy desert, and make its appearance on the banks of the Nile.

The sun entered the sixth sign about the time of harvest, which season was therefore represented by a Virgin, or female reaper, with an ear of corn in her hand.

At the autumnal equinox, when the sun enters Libra, the days and nights are equal all over the world, and seem to observe an equilibrium or balance. The sign was therefore represented under the symbol of a pair of Scales.

Autumn, which produces fruit in great abundance, brings with it a variety of diseases, and on this account was represented by that venomous animal, the Scorpion, which, as he recedes, wounds with a sting in his tail. The fall of the leaf, was the season for hunting, and the stars which mark the sun's path at this time were represented by a huntsman, or archer, with his arrows and weapons of destruction.

The Goat, which delights in climbing and ascending some mountain or precipice, is the emblem of the winter solstice, when the sun begins to ascend from the southern tropic, and gradually to increase in height for the ensuing half year.

Aquarius, or the Water-Bearer, is represented by the figure of a man pouring out water from an urn, an emblem of the dreary and uncomfortable season of winter.

The last of the zodiacal constellations was Pisces, or a couple of fishes, tied back to back, representing the fishing season. The severity of winter is over; the flocks do not afford sustenance, but the seas and rivers are open and abound with fish.

"Thus monstrous forms, o'er heaven's nocturnal arch,
Seen by the sage, in pomp celestial march;
See Aries there his glittering bow unfold,
And raging Taurus toss his horns of gold;
With bended bow the sullen Archer lowers,
And there Aquarius comes with all his showers;

What sign was represented under the figure of a Crab, and why? When does the sun enter this sign? What animal represented the heat of summer, and why? When does the sun enter the sixth sign, and how is this season represented? Why was the sign which the sun enters at the autumnal equinox represented under the symbol of a Balance? Why were the autumnal signs, Scorpio and Sagittarius, represented as they are? What does the Goat represent? What is signified by the Water-Bearer? What do the Fishes represent?

Lions and Centaurs, Gorgons, Hydras rise,
And gods and heroes blaze along the skies."*

Whatever may have led to the adoption of these rude names at first, they are now retained to avoid confusion.

The early Greeks, however, displaced many of the Chaldean constellations, and substituted such images in their place as had a more special reference to their own history. The Romans, also pursued the same course with regard to *their* history; and hence the contradictory accounts that have descended to later times.

Some, moreover, with a desire to divest the science of the stars of its pagan jargon and profanity, have been induced to alter both the names and figures of the constellations. In doing this, they have committed the opposite fault; that of blending them with things sacred. The "venerable Bede," for example, instead of the profane names and figures of the twelve constellations of the Zodiac, substituted those of the *twelve apostles*. Julius Schillerius, following his example, completed the reformation in 1627, by giving Scripture names to all the constellations in the heavens. Weigelius, too, a celebrated professor of mathematics in the university of Jena, made a new order of constellations, by converting the firmament into a CŒLUM HERALDICUM, in which he introduced the arms of all the princes of Europe. But astronomers, generally, never approved of these innovations; and for ourselves, we had as lief the sages and heroes of antiquity should continue to enjoy their fiancied honors in the sky, as to see their places supplied by the princes of Europe.

The number of the old constellations, including those of the Zodiac, was only forty-eight. As men advanced in the knowledge of the stars, they discovered many, but chiefly in southern latitudes, which were not embraced in the old constellations, and hence arose that mixture of ancient and modern names which we meet with in modern catalogues.

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* The order of the signs is thus described by Dr. Watts:—
The *Ram*, the *Bull*, the heavenly *Twins*;
And, next the *Crab*, the *Lion* shines,
The *Virgin*, and the *Scales*;
The *Scorpion*, *Archer*, and *Sea-Goat*,
The *Man* that holds the *Water-Pot*,
And *Fish*, with glittering tails.

Similar to this are the Latin verses:—

Sunt, aries, taurus, gemini, cancer, leo, virgo,
Libraque, scorpius, arcitenens, caper, amphora, pisces.

Why have attempts been made to change the names and figures of the ancient constellations? What fault has been committed in doing this? What did the venerable Bede substitute for the profane names and figures of the twelve constellations of the Zodiac? Who followed his example, and to what extent? What other change was attempted, and by whom? Have astronomers generally approved of these innovations? What was the number of the old constellations? Whence is the mixture of ancient and modern names which we meet with in modern catalogues?

Astronomers divide the heavens into three parts, called the Northern and Southern Hemispheres, and the Zodiac. In the northern hemisphere, astronomers usually reckon thirty-four constellations, in the Zodiac twelve, and in the southern hemisphere forty-seven; making in all, ninety-three. Besides these, there are a few of inferior note, recently formed, which are not considered sufficiently important to be particularly described.

About the year 1603, John Bayer, a native of Germany, invented the convenient system of denoting the stars in each constellation by the letters of the Greek alphabet, applying to the largest star the first letter of the alphabet; to the next largest the second letter, and so on to the last. Where there are more stars in the constellation than there are Greek letters, the remainder are denoted by the letters of the Roman alphabet, and sometimes by figures. By this system of notation, it is now as easy to refer to any particular star in the heavens, as to any particular house in a populous city, by its street and number.

Before this practice was adopted, it was customary to denote the stars by referring them to their respective *situations in the figure* of the constellation to which they severally belonged, as the head, the arm, the foot, &c.

It is hardly necessary to remark that these figures, which are all very curiously depicted upon artificial globes and maps are, purely, a fanciful invention—answering many convenient ends, however, for purposes of reference and classification, as they enable us to designate with facility any particular star, or cluster of stars; though these clusters very rarely, if ever, represent the real figures of the object whose names they bear. And yet it is somewhat remarkable that the name of "Great Bear," for instance, should have been given to the very *same* constellation by a nation of American aborigines, (the Iroquois,) and by the most ancient Arabs of Asia, when there never had been any communication between them! Among other nations, also, between whom there exists no evidence of any intercourse, we find the Zodiac divided into the same number of constellations, and these distinguished by nearly the same names, representing the twelve months, or seasons of the year.

The history of this whimsical personification of the stars carries us back to the earliest times, and introduces us, as we have seen, to the languages and customs, the religion and

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How do astronomers usually divide the heavens, and what is the number of constellations in each division? What convenient system of notation has been invented for denoting the stars in each constellation? Who invented this system? Before this method was introduced, what was the practice?

poetry, the sciences and arts, the tastes, talents, and peculiar genius, of the early nations of the earth. The ancient Atlantides and Ethiopians, the Egyptian priests, the magi of Persia, the shepherds of Chaldea, the Bramins of India, the mandarins of China, the Phenician navigators, the philosophers of Greece, and the wandering Arabs, have all added more or less to these curious absurdities and ingenious inventions, and have thus registered among the stars, as in a sort of album, some memorial of themselves and of the times in which they lived. The constellations, or the uncouth figures by which they are represented, are a faithful picture of the ruder stages of civilization. They ascend to times of which no other record exists; and are destined to remain when all others shall be lost. Fragments of history, curious dates and documents relating to chronology, geography, and languages, are here preserved in imperishable characters. The adventures of the gods, and the inventions of men, the exploits of heroes, and the fancies of poets, are here spread out in the heavens, and perpetually celebrated before all nations. The Seven stars, and Orion, present themselves to us, as they appeared to Amos and Homer: as they appeared to Job, more than 3000 years ago, when the Almighty demanded of him—"Knowest thou the ordinances of heaven? Canst thou bind the sweet influences of the PLEIADES, or loose the bands of ORION? Canst thou bring forth MAZZAROTH in his season, or canst thou guide ARCTURUS with his sons?" Here, too, are consecrated the lyre of Orpheus and the ship of the Argonauts; and, in the same firmament, glitter the mariner's compass and the telescope of Herschel.

CHAPTER XVI.

NUMBER, DISTANCE, AND ECONOMY OF THE STARS.

THE first conjecture in relation to the distance of the fixed stars, is, that they are all placed at an equal distance from the observer, upon the visible surface of an immense concave vault, which rests upon the circular boundary of the world, and which we call the *Firmament*.

We can, with the unassisted eye, form no estimate of their respective distances; nor has the telescope yet enabled us to arrive at any exact results on this subject, although it has revealed to us many millions of stars that are as far removed

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What is the first conjecture which we form in relation to the distances of the fixed stars? What means have we for ascertaining their number and distance?

beyond those which are barely visible to the naked eye, as these are from us. Viewed through the telescope, the heavens become quite another spectacle—not only to the understanding, but to the senses. New worlds burst upon the sight, and old ones expand to a thousand times their former dimensions. Several of those little stars which but feebly twinkle on the unassisted eye, become immense globes. with land and water, mountains and valleys, encompassed by atmospheres, enlightened by moons, and diversified by day and night, summer and winter.

Beyond these are other suns, giving light and life to other systems, not a thousand, or two thousand merely, but multiplied without end, and ranged all around us, at immense distances from each other, attended by ten thousand times ten thousand worlds, all in rapid motion; yet calm, regular and harmonious—all space seems to be illuminated, and every particle of light a world.

It has been computed that *one hundred millions* of stars which cannot be discerned by the naked eye, are now visible through the telescope. And yet all this vast assemblage of suns and worlds may bear no greater proportion to what lies beyond the utmost boundaries of human vision, than a drop of water to the ocean; and, if stricken out of being, would be no more missed, to an eye that could take in the universe, than the fall of a single leaf from the forest.

We should therefore learn (says an eminent divine of the present century,*) not to look on our earth as the universe of God, but as a single, insignificant atom of it; that it is only one of the many mansions which the Supreme Being has created for the accommodation of his worshipers; and that he may now be at work in regions more distant than geometry ever measured, creating worlds more manifold than numbers ever reckoned, displaying his goodness, and spreading over all the intimate visitations of his care.

The immense distance at which the nearest stars are known to be placed, proves that they are bodies of a prodigious size, not inferior to our sun, and that they shine, not by reflected rays, but by their own native light. It is therefore concluded, with good reason, that every fixed star is a sun, no less spacious than ours, surrounded by a retinue of planetary worlds,

* Chalmers.

How do the heavens appear through the telescope? What are beyond those little stars which are scarcely visible to the naked eye? How many stars are visible through the telescope? What proportion may this vast assemblage of suns and worlds bear to what lies beyond the utmost boundaries of human vision? How should we learn from this to regard our own earth? What does the immense distance of the stars prove in regard to their magnitude and light?

which revolve around it as a center, and derive from it light and heat, and the agreeable vicissitudes of day and night.

These vast globes of light, then, could never have been designed merely to diversify the voids of infinite space, nor to shed a few glimmering rays on our far distant world, for the amusement of a few astronomers, who, but for the most powerful telescopes, had never seen the ten thousandth part of them. We may therefore rationally conclude, that *wherever* the All-wise Creator has exerted his creative power, *there* also he has placed intelligent beings to adore his goodness.

Hipparchus, the father of astronomy, first made a catalogue of the fixed stars. It contained 1022. The accuracy with which the places of these were recorded, has conferred essential benefit upon the science, and has enabled us to solve many celestial phenomena and problems of chronology, which otherwise had been difficult.

During the 18th century, upward of 100,000 were catalogued by the various astronomers of Europe, and their position in the heavens determined with an exactness that seldom varied a second from the truth; insomuch that it has been justly remarked, that "there is scarcely a star to be seen in the heavens, whose place and situation is not better known than that of most cities and towns upon the earth."

But the star-gazers of our times are not idle. Professor Bessel of Konigsberg, observed in three years, it is asserted, between 30,000 and 40,000 stars, comprehended within a zone of 15° on each side of the equator; but even this great number is but a small portion of the whole number which lie within the limit of the zone which he examined. To procure a more complete survey, the academy of Berlin proposed that *this same zone* should be parceled out among twenty-four observers, and that each should confine himself to an hour of right ascension, and examine it in minute detail. This plan was adopted; and the 18th hour was confided to Professor Inghirami, of Florence, and examined with so much care, that the positions of 75,000 stars in it have been determined. Professor M. Struve, of the Dorpat university, has examined in person 120,000 stars, of which 800 (double ones) were before unknown to science.

The labors of Sir Wm. Herschel were chiefly devoted to exploring the systems of nebulæ and double stars that lie, for the most part, beyond the reach of ordinary telescopes. No fewer than *two thousand five hundred* nebulæ were observed by this indefatigable astronomer, whose places have been computed from his observations, reduced to a common epoch, and arranged into a catalogue in order of their right ascension, by his sister MISS CAROLINE HERSCHEL, a lady so justly celebrated in Europe for her astronomical knowledge and discoveries, but whose name, strange as it is, is seldom mentioned in this country. Be it remembered, nevertheless, for her fame, that she discovered two of the satellites of the planet which bears her brother's name, besides a multitude of comets.

The greatest possible ingenuity and pains have been taken by astronomers to determine, at least, the approximate distance of the nearest fixed stars. If they have hitherto been unable to arrive at any satisfactory result, they have, at least, established a limit beyond which the stars must necessarily be placed. If they have failed to calculate their true distances from the earth, it is because they have not the requisite data. The solution of the problem, if they had the data, would not be more difficult than to compute the relative dis-

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What conclusion may be drawn from this fact as to their great design? What pains have astronomers taken to find the distance of the stars, and what result have they come to? For what reason have they failed to calculate their distance? Is the problem a difficult one?

tances of the planets—a thing which any school-boy can do. In estimating so great a distance as the nearest fixed star, it is necessary that we employ the longest measure which astronomy can use. Accordingly, we take the whole diameter of the earth's orbit, which, in round numbers, is 190 millions of miles, and endeavor, by a simple process in mathematics, to ascertain how many measures of this length are contained in the mighty interval which separates us from the stars.

The method of doing this can be explained to the apprehension of the pupil, if he does not shrink from the illustration, through an idle fear that it is beyond his capacity.

For example; suppose that, with an instrument constructed for the purpose, we should this night take the precise bearing or angular direction from us of some star in the northern hemisphere, and note it down with the most perfect exactness, and, having waited just six months, when the earth shall have arrived at the opposite point of its orbit, 190 millions of miles east of the place which we now occupy, we should then repeat our observation upon the same star, and see how much it had changed its position by our traveling so great a distance one side of it. Now, it is evident, that if it changes its apparent position at all, the *quantity* of the change will bear some proportion to the distance gone over; that is, the *nearer* the star, the *greater* the angle; and the more *remote* the star, the *less* the angle. It is to be observed, that the angle thus found, is called the star's *Annual Parallax*.

But it is found by the most eminent astronomers of the age, and the most perfect instruments ever made, that this parallax does not exceed the *four thousandth part of a degree*, or a single second; so that, if the whole great orbit of the earth were lighted up into a globe of fire 600 millions of miles in circumference, it would be seen by the nearest star only as a twinkling atom; and to an observer placed at this distance, our sun, with its whole retinue of planetary worlds, would occupy a space scarcely exceeding the thickness of a spider's web.* If the nearest of the fixed stars are placed at

* A just idea of the import of this term, will impart a force and sublimity to an expression of St. James, which no power of words could improve. It is said, Chapter I. verse 17, of Him from whom cometh down every good and perfect gift, that there is "*ουκ ενι παραλλαγη η τροπης αποσκιασμα.*" Literally, There is "*neither parallax nor shadow of change:*" As if the apostle had said—Peradventure, that in traveling millions and millions of miles through the regions of immensity, there may be a sensible parallax to some of the fixed stars; yet, as to the Father of Lights, view him from whatever point of his empire we may, *he is without parallax or shadow of change!*

What measure is employed in estimating the distances of the fixed stars? How is it used? What is the angle thus found called? What is the greatest magnitude of the annual parallax?

such inconceivable distances in the regions of space, with what line shall we measure the distance of those which are a thousand or a million of times as much farther from them, as these are from us?

If the annual parallax of a star were accurately known, it would be easy to compute its distance by the following rule:

As the sine of the star's parallax:
Is to radius, or ninety degrees::
So is the earth's distance from the sun:
To the star's distance from the sun.

If we allow the annual parallax of the nearest star to be 1″, the calculation will be,

As 0.0000048481368=Nat. Sine of 1″.
Is to 1.0000000000000=Nat. Sine of 90°.
So is 95,273,868.867748554=Earth's distance from the sun.
To 19,651,627,683,449=Star's distance from the sun.

In this calculation we have supposed the earth to be placed at the mean distance of 24,047 of its own semi-diameters, or 95,273,868.867748554 miles from the sun, which makes the star's distance a very little less than twenty billions of miles. Dr. Herschel says that Sirius cannot be nearer than 100,000 times the diameter of the earth's orbit, or 19,007,788,800.000 of miles.

Biot, who either takes the earth's distance *greater* than he lays it down in his *Traite' Elementaire d'Astronomie Physique*, or has made an error in figures, makes the distance 20,086,868,036.404. Dr. Brewster makes it 20,159,665.000,000 miles. A mean of these computations, is 20 billions; that is, 20 millions of millions of miles, to a parallax of 1″.

Astronomers are generally agreed in the opinion that the annual parallax of the stars is less than 1″, and consequently that the nearest of them is placed at a much greater distance from us, than these calculations make it. It was, however, announced during the last year, that M. d'Assas, a French astronomer, had satisfactorily established the annual parallax of *Keid*, (a small star 8° N. of Gamma Eridani,) to be 2″, that of *Rigel*, in Orion, to be 1″.43, and that of *Sirius* to be 1″. 24. If these results may be relied on, Keid is but 10 billions, Rigel but 14 billions, and Sirius 16 billions of miles from the earth. This latter distance is, however, so great that, if Sirius were to fall toward the earth at the rate of a million of miles a day, it would take it forty-three thousand, three hundred years to reach the earth; or, if the Almighty were now to blot it out of the heavens, its brilliance would continue undiminished in our hemisphere for the space of three years.

The most brilliant stars, till recently, were supposed to be situated nearest the earth, but later observations prove that this opinion is not well founded, since some of the smaller stars appear to have, not only a greater annual parallax, but an absolute motion in space, much greater than those of the brightest class.

What conclusion may be drawn from this fact in regard to the distances of the fixed stars? If the annual parallax of a star were known, by what simple rule could you compute its distance? If we allow the annual parallax of the nearest star to be 1″ what will its distance be? *What is a mean of the calculations of different astronomers for a parallax of 1″? What recent observations indicate a greater parallax to some of the stars? If the parallax of Sirius be 1″.24, what will be its distance? How long would it require, passing through this distance, at the rate of a million of miles a day, to reach the earth, and how long would its light continue undiminished to us, were it to be blotted from the heavens?* What has been supposed to be the relative distance of the most brilliant stars from the earth? What do later observations prove, in regard to this opinion?

It has been computed that the light of Sirius, although twenty thousand million times less than that of our sun, is nevertheless, three hundred and twenty-four times greater than that of a star of the sixth magnitude. If we suppose the two stars to be really of the same size, it is easy to show that the star of the sixth magnitude is fifty-seven and one third times farther from us than Sirius is, because light diminishes as the square of the distance of the luminous body increases.

By the same reasoning it may be shown, that if Sirius were placed where the sun is, it would appear to us to be four times as large as the sun, and give four times as much light and heat. It is by no means unreasonable to suppose, that many of the fixed stars exceed a million of miles in diameter.

We may pretty safely affirm, then, that stars of the sixth magnitude are not less than 900 millions of millions of miles distant from us ; or a million of times farther from us than the planet Saturn, which is scarcely visible to the naked eye. But the human mind in its present state, can no more appreciate such distances than it can infinity; for if our earth, which moves at more than the inconceivable velocity of a million and a half of miles a day, were to be hurried from its orbit, and to take the same rapid flight over this immense tract, it would not traverse it in sixteen hundred thousand years; and every ray of light, although it moves at the rate of one hundred and ninety-three thousand miles in a single second of time, is more than one hundred and seventy years in coming from the star to us.

But what is even this, compared with that measureless extent which the discoveries of the telescope indicate? According to Dr. Herschel, the light of some of the nebulæ, just perceptible through his 40 feet telescope, must have been a million of ages in coming to the earth; and should any of them be now destroyed, they would continue to be perceptible for a million of ages to come.

Dr. Herschel informs us, that the glass which he used would separate stars at 497 times the distance of Sirius.

It is one of the wonders of creation that any phenomena of bodies at such an immense distance from us should be perceptible by human sight; but it is a part of the Divine Maker's plan, that although they do not act physically upon us, yet they should so far be objects of our perception, as

Suppose the light of Sirius to be twenty thousand million times less than that of our sun, how would it compare with that of a star of the sixth magnitude? If we suppose the two stars to be of the same size, how much farther off is the star of the sixth magnitude, than Sirius is? *Suppose Sirius to be placed where our sun is, how would its apparent magnitude, and its light and heat compare with those of the sun?* What may we generally affirm of the distance of stars of the sixth magnitude? Can the human mind appreciate such distances? What illustrations can you give to show their immensity? What is this distance compared with that of the telescopic stars, and the nebulæ? Why are we able to see bodies at so great a distance?

to expand our ideas of the vastness of the universe, and of the stupendous extent and operations of his omnipotence.

"With these facts before us," says an eminent astronomer and divine, "it is most reasonable to conclude, that those expressions in the Mosaic history of Creation, which relate to the creation of the fixed stars, are not to be understood as referring to the *time* when they were brought into existence, as if they had been created about the same time with our earth; but as simply declaring the fact, that, at whatever period in duration they were created, *they derived their existence from God.*"

"That the stars here mentioned," (*Gen.* i. 16,) says a distinguished commentator,* "were the planets of our system, and not the fixed stars, seems a just inference from the fact, that after mentioning them, Moses immediately subjoins, 'And Elohim set them in the firmament of the heaven to give light upon the earth, and to rule over the day and over the night;' evidently alluding to Venus and Jupiter, which are alternately our morning and evening stars, and which 'give light upon the earth,' far surpassing in brilliancy any of the fixed stars."

However vast the universe now appears, however numerous the worlds which may exist within its boundless range, the language of Scripture, and Scripture alone, is sufficiently comprehensive and sublime, to express all the emotions which naturally arise in the mind, when contemplating its structure. This shows not only the harmony which subsists between the discoveries of the Revelation and the discoveries of Science, but also forms, by itself, a strong presumptive evidence, that the records of the Bible are authentic and divine.

We have hitherto described the stars as being immovable and at rest; but from a series of observations on double stars, Dr. Herschel found that a great many of them have changed their situations with regard to each other; that some perform revolutions about others, at known and regular periods, and that the motion of some is direct, while that of others is retrograde; and that many of them have dark spots upon their surface, and turn on their axis, like the sun.

A remarkable change appears to be gradually taking place in the relative distances of the stars from each other in the constellation Hercules. The stars in this region appear to be spreading farther and farther apart, while those in the opposite point of the heavens seem to close nearer and nearer together, in the same manner as when walking through a

* S. Turner, F. S. A. R. A. S. L., 1832.

With these facts before us, what may we reasonably conclude with regard to the expressions in the Mosaic history which relate to the creation of the fixed stars? What is the opinion of Mr. Turner in regard to the stars here mentioned? To what is the expression "To rule over the day and over the night," supposed to allude? Give some account of the real motions of the fixed stars. What remarkable changes are taking place in the constellation Hercules?

forest, the trees toward which we advance, appear to be constantly separating, while the distance between those which we leave behind, is gradually contracting.

From this appearance it is concluded, that the sun, with all its retinue of planetary worlds, is moving through the regions of the universe, toward some distant center, or around some wide circumference, at the rate of sixty or seventy thousand miles an hour; and that it is therefore highly probable, if not absolutely certain, that we shall never occupy that portion of *absolute space*, through which we are at this moment passing, during all the succeeding ages of eternity.*

The author of the CHRISTIAN PHILOSOPHER endeavors to convey some idea of the boundless extent of the universe, by the following sublime illustration:—

"Suppose that one of the highest order of intelligences is endowed with a power of rapid motion superior to that of light, and with a corresponding degree of intellectual energy; that he has been flying without intermission, from one province of creation to another, for six thousand years, and will continue the same rapid course for a thousand million years to come, it is highly probable, if not absolutely certain, that, at the end of this vast tour, he would have advanced no farther than the 'suburbs of creation,'—and that all the magnificent systems of material and intellectual beings he had surveyed, during his rapid flight, and for such a length of ages, bear no more proportion to the whole empire of Omnipotence, than the smallest grain of sand does to all the particles of matter contained in ten thousand worlds."

Were a seraph, in prosecuting the tour of creation in the manner now stated, ever to arrive at a limit beyond which no farther displays of the Divinity could be perceived, the thought would overwhelm his faculties with unutterable emotions; he would feel that he had now, in some measure, comprehended all the plans and operations of Omnipotence, and that no farther manifestation of the Divine glory remained to be explored. But we may rest assured that this can never happen in the case of any created intelligence.

There is moreover an argument derivable from the laws of the physical world, that seems to strengthen, I had almost said, to confirm, this idea of the *Infinity* of the material universe. It is this—*If the number of stars be finite, and occupy only a part of space, the outward stars would be continually attracted*

* Professor Bessel does not fall in with this prevailing opinion.

What conclusion is drawn from this appearance? Shall we then probably ever occupy that portion of space through which we are now passing again? What illustration does the author of the Christian Philosopher give in order to convey some idea of the boundless extent of the universe? Were a seraph ever to arrive at a limit beyond which no farther displays of the divine glory could be perceived, how would the idea affect him? Is it probable that such a place exists in the universe, or within the scope of any created intelligence?

to those within, and in time would unite in one. But if the number be infinite, and they occupy an infinite space, all parts would be nearly in equilibrio, and consequently each fixed star, being equally attracted in every direction, would keep its place.

No wonder, then, that the Psalmist was so affected with the idea of the immensity of the universe, that he seems almost afraid lest he should be overlooked amidst the immensity of beings that must needs be under the superintendence of God; or that any finite mortal should exclaim, when contemplating the heavens—"What is *man*, that THOU art mindful of him!"

CHAPTER XVII.

FALLING, OR SHOOTING STARS.

THE phenomenon of shooting stars, as it is called, is common to all parts of the earth; but is most frequently seen in tropical regions. The unerring aim, the startling velocity, and vivid brightness with which they seem to dart athwart the sky, and as suddenly expire, excite our admiration; and we often ask, "What can they be?"

But frequent as they are, this interesting phenomenon is not well understood. Some imagine that they are occasioned by electricity, and others, that they are nothing but luminous gas. Others again have supposed, that some of them are luminous bodies which accompany the earth in its revolution around the sun, and that their return to certain places might be calculated with as much certainty and exactness as that of any of the comets.

Dr. Burney of Gosport, kept a record of all that he observed in the course of several years. The number which he noticed in 1819, was 121, and in 1820, he saw 131. Professor Green is confident that a much larger number are annually seen in the United States.

Signior Baccaria supposed they were occasioned by electricity, and thinks this opinion is confirmed by the following observations. About an hour after sunset, he and some friends, that were with him, observed a falling star directing its course directly toward them, and apparently growing larger and larger, but just before it reached them it disap-

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Where does the phenomenon of falling, or shooting stars occur? What is there to excite our admiration in this phenomenon? Is this interesting phenomenon well understood? What are the different opinions in regard to them? How many shooting stars did Dr. Burney observe in the years 1819 and 1820? Is it probable that a much larger number is seen every year in the United States? What did Baccaria suppose they were occasioned by, and what observations did he make to strengthen his opinion?

peared. On vanishing, their faces, hands, and clothes, with the earth and all the neighboring objects, became suddenly illuminated with a diffused and lambent light. It was attended with no noise. During their surprise at this appearance, a servant informed them, that he had seen a light shine suddenly in the garden, and especially upon the streams which he was throwing to water it.

The Signior also observed a quantity of electric matter collect about his kite, which had very much the appearance of a falling star. Sometimes he saw a kind of halo accompanying the kite, as it changed its place, leaving some glimmering of light in the place it had quitted.

Shooting stars have been supposed by those meteorologists who refer them to electricity or luminous gas, to prognosticate changes in the weather, such as rain, wind, &c.; and there is, perhaps, some truth in this opinion. The duration of the brilliant tract which they leave behind them, in their motion through the air, will probably be found to be longer or shorter, according as watery vapor abounds in the atmosphere.

The notion that this phenomenon betokens high winds, is of great antiquity. Virgil, in the first book of his Georgics, expresses the same idea:—

> "Sæpe etiam stellas vento impendente videbis
> Præcipites cœlo labi; noctisque per umbram
> Flammarum longos a tergo albescere tractus.
>
> And oft, before tempestuous winds arise,
> The *seeming* stars fall headlong from the skies,
> And shooting through the darkness, gild the night
> With sweeping glories and long trails of light."

The number of shooting stars, observed in a single night, though variable, is commonly very small. There are, however, several instances on record of their falling in "showers" —when every star in the firmament seems loosened from its sphere, and moving in lawless flight from one end of the heavens to the other. As early as the year 472, in the month of November, a phenomenon of this kind took place near Constantinople. As Theophanes relates, "the sky appeared to be on fire," with the coruscations of the flying meteors.

A shower of stars, exactly similar took place in Canada, between the 3d and 4th of July, 1814, and another at Montreal, in November, 1819. In all these cases, a residuum, or *black dust*, was deposited upon the surface of the waters, and upon the roofs of buildings, and other objects. In the year 1810, "inflamed substances," it is said, fell into and around lake Van, in Armenia, which stained the water of a blood color, and cleft the earth in various places. On the 5th of

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What was the appearance upon streams of water? What did he observe at this time about his kite? What connection are they supposed to have with meteorology? What circumstance may we probably find to confirm this idea? Is this notion of very ancient, or modern date? What is, usually, the number of shooting stars observed in a single night? When, and where, occurred the first instance, on record, of their falling in great numbers? Mention some other instances. *What remarkable vestige was left by these meteoric showers?*

September, 1819, a like phenomenon was seen in Moravia. History furnishes many more instances of meteoric showers, depositing a *red dust* in some places, so plentiful as to admit of chemical analysis.

The commissioner, (Mr. Andrew Ellicott,) who was sent out by our government to fix the boundary between the Spanish possessions in North America and the United States, witnessed a very extraordinary flight of shooting stars, which filled the whole atmosphere from Cape Florida to the West India Islands. This grand phenomenon took place the 12th of November, 1799, and is thus described :—"I was called up," says Mr. Ellicott, "about 3 o'clock in the morning, to see the shooting stars, as they are called. The phenomenon was grand and awful. The whole heavens appeared as if illuminated with sky-rockets, which disappeared only by the light of the sun, after daybreak. The meteors, which at any one instant of time, appeared as numerous as the stars, flew in all possible directions except *from* the earth, *toward* which they all inclined more or less, and some of them descended perpendicularly over the vessel we were in, so that I was in constant expectation of their falling on us."

Mr. Ellicott further states that his thermometer, which had been at 80° Fahr. for the four days preceding, fell to 56° about 4 o clock, A. M., and that nearly at the same time, the wind changed from the south to the north-west, from whence it blew with great violence for three days without intermission.

These same appearances were observed, the same night, at Santa Fe de Bogota, Cumana, Quito, and Peru, in South America; and as far north as Labrador and Greenland, extending to Weimar in Germany, being thus visible over an extent on the globe of 64° of latitude, and 94° of longitude.

The celebrated Humboldt, accompanied by M. Bompland, then in S. America, thus speaks of the phenomenon :—"Toward the morning of the 13th of November, 1799, we witnessed a most extraordinary scene of shooting meteors. Thousands of *bolides*, and falling stars succeeded each other during four hours. Their direction was very regular from north to south. From the beginning of the phenomenon there was not a space in the firmament, equal in extent to three diameters of the moon, which was not filled every instant with *bolides* or falling stars. All the meteors left luminous traces, or phosphorescent bands behind them, which lasted seven or eight seconds."

This phenomenon was witnessed by the Capuchin missionary at San Fernando de Afiura, a village situated in lat. 7° 53′ 12″, amidst the savannahs of the province of Varinas; by the Franciscan monks stationed near the cataracts of the Oronoco, and at Marca, on the banks of the Rio Negro, lat. 2° 40″, long 70° 21′, and in the west of Brazil, as far as the equator itself; and also at the city of Porto Cabello, lat. 10° 6′ 52″, in French Guiana, Popayan, Quito, and Peru. It is somewhat surprising that the same appearances, observed in places so widely separated, amid the vast and lonely deserts of South America, should have been seen, the same night, in the United States, in Labrador, in Greenland, and at Itterstadt, near Weimar, in Germany!

Recite instances of a similar kind, in which a red dust has been deposited. Describe the phenomenon of shooting stars described by Mr. Ellicott, in 1799. *Describe the same phenomenon as seen, in South America, by Humboldt and others. In what other parts of the earth was it witnessed, and by whom?*

We are told that thirty years before, at the city of Quito, "there was seen in one part of the sky, above the volcano of Cayamburo, so great a number of falling stars, that the mountain was thought to be in flames. This singular sight lasted more than an hour. The people assembled in the plain of Exida, where a magnificent view presents itself of the highest summits of the Cordilleras. A procession was already on the point of setting out from the convent of St. Francis, when it was perceived that the blaze on the horizon was caused by fiery meteors, which ran along the sky in all directions, at the altitude of 12 or 13 degrees."

But the most sublime phenomenon of shooting stars, of which the world has furnished any record, was witnessed throughout the United States on the morning of the 13th of November, 1833.

The entire extent of this astonishing exhibition has not been precisely ascertained, but it covered no inconsiderable portion of the earth's surface. It has been traced from the longitude of 61°, in the Atlantic ocean, to longitude 100° in Central Mexico, and from the North American lakes to the West Indies.

It was not seen, however, any where in Europe, nor in South America, nor in any part of the Pacific ocean yet heard from.

Every where, within the limits above mentioned, the first appearance was that of fireworks of the most imposing grandeur, covering the entire vault of heaven with myriads of fire-balls, resembling sky-rockets. Their coruscations were bright, gleaming and incessant, and they fell thick as the flakes in the early snows of December. To the splendors of this celestial exhibition, the most brilliant sky-rockets and fireworks of art, bear less relation than the twinkling of the most tiny star to the broad glare of the sun. The whole heavens seemed in motion, and suggested to some the awful grandeur of the image employed in the apocalypse, upon the opening of the sixth seal, when "the stars of heaven fell unto the earth, even as a fig-tree casteth her untimely figs, when she is shaken of a mighty wind."

One of the most remarkable circumstances attending this display was, that the meteors all seemed to emanate from one and the same point, a little south-east of the zenith. Following the arch of the sky, they ran along with immense velocity

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Describe another phenomenon of a similar kind, seen in South America about thirty years before? When occurred the most sublime phenomenon of shooting stars of which the world has any record? How extensively was it witnessed? What was the first appearance of the phenomenon? What scene in the *apocalypse* did it suggest to some? From what point did the meteors appear to emanate? Describe their motion.

describing, in some instances, an arc of 30° or 40° in a few seconds.

On more attentive inspection it was seen, that the meteors exhibited three distinct varieties; the *first*, consisting of *phosphoric lines*, apparently described by a point; the *second*, of large *fire-balls*, that at intervals darted along the sky, leaving luminous trains, which occasionally remained in view for a number of minutes, and, in some cases, for half an hour or more; the third, of undefined *luminous bodies*, which remained nearly stationary in the heavens for a long time.

Those of the first variety were the most numerous, and resembled a shower of fiery snow driven with inconceivable velocity to the north of west. The second kind appeared more like *falling* stars—a spectacle which was contemplated by the more unenlightened beholders with great amazement and terror. The trains which they left were commonly white, but sometimes were tinged with various prismatic colors, of great beauty.

These fire-balls were occasionally of enormous size. Dr. Smith, of North Carolina, describes one which appeared larger than the full moon rising.* "I was," says he, "startled by the splendid light in which the surrounding scene was exhibited, rendering even small objects quite visible." The same ball, or a similar one, seen at New Haven, passed off in a north-west direction, and exploded a little northward of the star Capella, leaving, just behind the place of explosion, a train of peculiar beauty. The line of direction was at first nearly straight; but it soon began to contract in length, to dilate in breadth, and to assume the figure of a serpent SCROLLING itself up, until it appeared like a luminous cloud of vapor, floating gracefully in the air, where it remained in full view for several minutes.

Of the third variety of meteors, the following are remarkable examples:—At Poland, Ohio, a luminous body was distinctly visible in the north-east for more than an hour. It was very brilliant, in the form of a *pruning-hook*, and apparently twenty feet long, and eighteen inches broad. It gradually

* If this body were at the distance of 110 miles from the observer, it must have had a diameter of one mile; if at the distance of 11 miles, its diameter was 528 feet: and if only one mile off, it must have been 48 feet in diameter. These considerations leave no doubt that many of the meteors were bodies of *large size*.

What other appearances were observed upon more attentive inspection? Give a more particular account of the first variety. Of the second. What do we know in regard to the size of these fire-balls? How does Dr. Smith describe one seen by him in North Carolina? What was the appearance of the same or a similar ball, as seen at New Haven? What was there peculiar in the course, and final disappearance of it? *Suppose this meteor was 110 miles distant from the place of observation, what must have been its diameter? What, if it were 11 miles distant? What, if only one mile?* Mention some examples of the third variety of meteors.

settled toward the horizon, until it disappeared. At Niagara Falls, a large, luminous body, shaped like a *square table*, was seen near the zenith, remaining for some time almost stationary, emitting large streams of light.

The point from which the meteors seemed to emanate, was observed, by those who fixed its position among the stars, to be in the constellation Leo; and, according to their concurrent testimony, this RADIANT POINT was stationary among the stars, during the whole period of observation; that is, it did not move along with the earth, in its diurnal revolution eastward, but accompanied the stars in their apparent progress westward.

A remarkable *change of weather* from warm to cold, accompanied the meteoric shower, or immediately followed it. In all parts of the United States, this change was remarkable for its suddenness and intensity. In many places, the day preceding had been unusually warm for the season, but, before the next morning, a severe frost ensued, unparalleled, for the time of year.

In attempting to explain these mysterious phenomena, it is argued, in the first place, *that the meteors had their origin beyond the limits of our atmosphere;* that they of course did not belong to this earth, but to the regions of space exterior to it.

The reason on which this conclusion is founded is this:—All bodies near the earth, including the atmosphere itself, have a common motion with the earth around its axis from west to east; but the *radiant point*, that indicated the source from which the meteors emanated, followed the course of the stars from east to west; therefore, it was independent of the earth's rotation, and consequently, at a great distance from it, and beyond the limits of the atmosphere. The *height* of the meteoric cloud, or radiant point, above the earth's surface, was, according to the mean average of Professor Olmsted's observations, not less than 2238 miles.

That the meteors were constituted of very light, combustible materials, seems to be evident, from their exhibiting the actual phenomena of combustion, they being consumed, or converted into smoke, with intense light; and the extreme tenuity of the substance composing them is inferred from the fact that they were stopped by the resistance of the air. Had their quantity of matter been considerable, with so prodigious a velocity, they would have had sufficient momentum to dash them upon the earth; where the most disastrous consequences might have followed.

In what constellation was the point from which the meteors seemed to radiate? What changes were observed in the weather during or soon after this phenomenon? In attempting to account for these phenomena, what hypothesis has been advanced in regard to the place where the meteors had their origin? *What is the reasoning by which this hypothesis is sustained? How high was the meteoric cloud supposed to be above the earth?* What do we know in regard to the substance of which the meteors were composed? What might have been the consequences, if their quantity of matter had been considerable?

The momentum of even light bodies of such size, and in such numbers, traversing the atmosphere with such astonishing velocity, must have produced extensive derangements in the atmospheric equilibrium. Cold air from the upper regions would be brought down to the earth; the portions of air incumbent over districts of country remote from each other, being mutually displaced, would exchange places, the air of the warm latitudes be transferred to colder, and that of cold latitudes to warmer regions.

Various *hypotheses* have been proposed to account for this wonderful phenomena. The agent which most readily suggests itself in this, and in many other unexplained natural appearances, is *electricity*. But no known properties of electricity are adequate to account for the production of the meteors, for the motions, or for the trains which they, in many instances, left behind them. Others, again, have referred their proximate cause to *magnetism*, and to *phosphoretted hydrogen;* both of which, however, seem to be utterly insufficient, so far as their properties are known, to account for so unusual a phenomenon.

Professor Olmsted, of *Yale College*, who has taken much pains to collect facts, and to establish a permanent theory for the periodical recurrence of such phenomena, came to the conclusion, that—

The meteors of November 13*th*, 1833, *emanated from a nebulous body, which was then pursuing its way along with the earth around the sun; that this body continues to revolve around the sun, in an elliptical orbit—but little inclined to the plane of the ecliptic, and having its aphelion near the orbit of the earth; and finally, that the body has a period of nearly six months, and that its perihelion is a little below the orbit of Mercury.*

This theory at least accommodates itself to the remarkable fact, that almost all the phenomena of this description, which are known to have happened, have occurred in the two opposite months of April and November. A similar exhibition of meteors to that of November, 1833, was observed on the same day of the week, April 20th, 1803, at Richmond, in Virginia, Stockbridge, Massachusetts, and at Halifax, in British America. Another was witnessed in the autumn of 1818, in the North Sea, when, in the language of the observers, "all the surrounding atmosphere was enveloped in one expansive sea of fire, exhibiting the appearance of another Moscow in flames."

Exactly *one year previous* to the great phenomenon of 1833, namely, on the 12th of November, 1832, a similar me-

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What effect must the momentum of even light bodies of such size, moving with such velocity, have had upon the atmosphere? Mention some hypotheses which have been proposed to account for these meteors. To what conclusion did Professor Olmsted, after a long investigation, come, in regard to them? To what remarkable facts in such phenomena, is this theory adapted? At what other corresponding periods have similar phenomena been observed?

teoric display was seen near *Mocha*, on the *Red Sea*, by Capt. Hammond and crew, of the ship Restitution.

A gentleman in *South Carolina* thus describes the effect of the phenomenon of 1833 upon his ignorant blacks:—"I was suddenly awakened by the most distressing cries that ever fell on my ears. Shrieks of horror, and cries of mercy, I could hear from most of the negroes of three plantations, amounting in all to about six or eight hundred. While earnestly listening for the cause, I heard a faint voice near the door calling my name; I arose, and taking my sword, stood at the door. At this moment, I heard the same voice still beseeching me to rise, and saying, 'O! my God, the world is on fire!' I then opened the door, and it is difficult to say which excited me most—the awfulness of the scene, or the distressed cries of the negroes; upward of one hundred lay prostrate on the ground—some speechless, and some with the bitterest cries, but most with their hands raised, imploring God to save the world and them. The scene was truly awful; for never did rain fall much thicker, than the meteors fell toward the earth; east, west, north, and south, it was the same!"

Since the preceding went to press, the author has been politely furnished, by Professor Olmsted, with the accompanying communication.

"I am happy to hear that you propose to stereotype your 'Geography of the Heavens.' It has done much, I believe, to diffuse a popular knowledge of astronomy, and I am pleased that your efforts are rewarded by an extended patronage.

"Were I now to express my views on the subject (*Meteoric Showers*) in as condensed a form as possible, I should state them in some such terms as the following: The meteoric showers which have occurred for several years past on or about the 13th of November, are characterized by four peculiarities, which distinguished them from ordinary shooting stars. First, they are far more numerous than common, and are larger and brighter. Secondly, they are in much greater proportion than usual, accompanied by luminous trains. Thirdly, they mostly appear to radiate from a common center; that is, were their paths in the heavens traced backward, they would meet in the same part of the heavens: this point has for three years past, at least, been situated in the constellation Leo. Fourthly, the greatest display is every where at nearly the same time of night, namely, from three to four o'clock—a time about half-way from midnight to sunrise. The meteors are inferred to consist of *combustible* matter, because they are seen to take fire and burn in the atmosphere. They are known to be very light, because, although they fall toward the earth with immense velocity, few, if any, ever reach the earth, but are arrested by the air, like a wad fired from a piece of artillery. Some of them are inferred to be bodies of comparatively *great size*, amounting in diameter to several hundred feet, at least, because they are seen under so large an angle, while they are at a great distance from the spectator. Innumerable small bodies, thus consisting of extremely light, thin, combustible matter, existing together in space far beyond the limits of the atmosphere, are believed to compose a body of immense extent, which has been called 'the nebulous body.' Only the *skirts* or extreme portions of this are brought down to the earth, while the entire extent occupies many thousand, and perhaps several millions of miles. This nebulous body is inferred to have a revolution around the sun, as well as the earth, and to come very near to the latter about the 13th of November each year. This annual meeting every year, for several years in succession, could not take place unless the periodic time of the nebulous body is either nearly a year, or half a year. Various reasons have induced the belief that half a year is the true period; but this point is considered as somewhat doubtful. The *zodiacal* light, a faint light that appears at different seasons of the year, either immediately preceding the morning or following the evening twilight, ascending from the sun in a triangular form, is, with some degree of probability, thought to be the nebular body itself, although the existence of such a body, revolving in the solar system, was inferred to be the cause of the meteoric showers, before any connection of it with the zodiacal light was even thought of."

GENERAL PHENOMENA

OF THE

SOLAR SYSTEM.

CHAPTER XVIII.

Our attention has hitherto been directed to those bodies which we see scattered every where throughout the whole celestial concave. These bodies, as has been shown, twinkle with a reddish and variable light, and appear to have always the same position with regard to each other. We know that their number is very great, and that their distance from us is immeasurable. We are also acquainted with their comparative brightness and their situation. In a word, we have before us their few visible appearances, to which our knowledge of them is well nigh limited; almost all our reasonings in regard to them being founded on *comparatively* few and uncertain analogies. Accordingly, our *chief* business thus far has been to detail their number, to describe their brightness and positions, and to give the names by which they have been designated.

There now remain to be considered certain other celestial bodies, all of which, from their remarkable appearance and changes, and some of them from their intimate connection with the comfort, convenience, and even existence of man, must have always attracted especial observation, and been objects of the most intense contemplation and the deepest interest. Most of these bodies are situated within the limits of the Zodiac. The most important of them are, the Sun, so superior to all the heavenly bodies for its apparent magnitude, for the light and heat which it imparts, for the marked effects of its changes of position with regard to the Earth; and the Moon, so conspicuous among the bodies which give light by night, and from her soft and silvery brightness, so pleasing to behold; re-

To what particulars is our knowledge of the fixed stars, those heavenly bodies which we have heretofore been considering, well nigh confined? Where are the bodies which now remain to be considered situated? Which of them are the most important?

markable not only for changes of position, but for the varied phases or appearances which she presents, as she waxes from her crescent form through all her different stages of increase to a full orb, and wanes back again to her former diminished figure.

The partial or total obscuration of these two bodies, which sometimes occurs, darkness taking place even at mid-day, and the face of night, before lighted up by the Moon's beams, being suddenly shaded by their absence, have always been among the most striking astronomical phenomena, and so powerful in their influence upon the beholders, as to fill them with perplexity and fear. If we observe these two bodies, we shall find that, besides their apparent diurnal motion across the heavens, they exhibit other phenomena, which must be the effect of motion. The Sun during one part of the year will be seen to rise every day farther and farther toward the north, to continue longer and longer above the horizon, to be more and more elevated at mid-day, until he arrives at a certain limit; and then, during the other part, the order is entirely reversed. The Moon sometimes is not seen at all; and then, when she first becomes visible, appears in the west, not far from the setting Sun, with a slender crescent form; every night she appears at a greater distance from the setting Sun, increasing in size, until at length she is found in the east, just as the Sun is sinking below the horizon in the west.

The Sun, if his motions be attentively observed, will be found to have another motion, opposite to his apparent diurnal motion from east to west. This may be perceived distinctly, if we notice, on any clear evening, any bright star which is first visible after sunset, near the place where he sunk below the horizon. The following evening, the star will not be visible on account of the approach of the Sun, and all the stars on the east of it will be successively eclipsed by his rays, until he shall have made a complete apparent revolution in the heavens. These are the most obvious phenomena exhibited by these two bodies.

There are also situated within the limits of the Zodiac certain other bodies, which, at first view and on a superficial examination, are scarcely distinguishable from the fixed stars. But, observed more attentively, they will be seen to shine with a milder and steadier light, and, besides being carried round with the stars, in the apparent revolution of the great celestial concave, they will seem to change their

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Describe the most obvious phenomena of the Sun and Moon. Describe the most obvious phenomena of the planets.

places in the concave itself. Sometimes they are stationary; sometimes they appear to be moving from west to east, and sometimes to be going back again from east to west; being seen at sunset sometimes in the east, and sometimes in the west, and always apparently changing their position with regard to the earth, each other, and the other heavenly bodies. From their wandering, as it were, in this manner through the heavens, they were called by the Greeks πλανηται, planets, which signifies *wanderers.*

There also sometimes appear in the heavens bodies of a very extraordinary aspect, which continue visible for a considerable period, and then disappear from our view; and nothing more is seen of them, it may be, for years, when they again present themselves, and take their place among the bodies of the celestial sphere. They are distinguished from the planets by a dull and cloudy appearance, and by a train of light. As they approach the sun, however, their faint and nebulous light becomes more and more brilliant, and their train increases in length, until they arrive at their nearest point of approximation, when they shine with their greatest brilliancy. As they recede from the Sun, they gradually lose their splendor, resume their faint and nebulous appearance, and their train diminishes, until they entirely disappear. They have no well-defined figure; they seem to move in every possible direction, and are found in every part of the heavens. From their train, they were called by the Greeks κομηται, comets, which signifies having long hair.

The causes of these various phenomena must have early constituted a very natural subject of inquiry. Accordingly, we shall find, if we examine the history of the science, that in very early times there were many speculations upon this subject, and that different theories were adopted to account for these celestial appearances.

The Egyptians, Chaldeans, Indians, and Chinese, early possessed many astronomical facts, many observations of important phenomena, and many rules and methods of astronomical calculation; and it has been imagined, that they had the ruins of a great system of astronomical science, which, in the earliest ages of the world, had been carried to a great degree of perfection, and that while the principles and explanations of the phenomena were lost, the isolated, unconnected facts, rules of calculation, and phenomena themselves, remained. Thus, the Chinese, who, it is generally agreed, possess the oldest authentic observations on record, have recorded in their annals, a conjunction of five planets at the same time, which happened 2461 years before Christ, or 100 years before the flood. By mathematical calculation, it is ascertained that this conjunction really occurred at that time. The first observation of a solar eclipse of which the world has any knowledge, was made by the Chinese, 2128 years before Christ, or 220 years after the deluge. It seems, also, that the Chinese understood the method of calculating eclipses; for, it is said, that the emperor was so irritated against the

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Whence do they derive their name? Describe the comets. Whence is their name derived? *What oriental nations early possessed many important astronomical facts, observations, and rules? Whence is it supposed that they obtained them?*

great officers of state for neglecting to predict the eclipse, that he caused them to be put to death.* The astronomical epoch of the Chinese, according to Bailly, commenced with Fohi, their first emperor, who flourished 2952 years before the Christian era, or about 350 years before the deluge. If it be asked how the knowledge of this antediluvian astronomy was preserved and transmitted, it is said that the columns on which it was registered have survived the deluge, and that those of Egypt are only copies which have become originals, now that the others have been forgotten. The Indians, also, profess to have many celestial observations of a very early date. The Chaldeans have been justly celebrated in all ages for their astronomical observations. When Alexander took Babylon, his preceptor, Callisthenes, found a series of Chaldean observations, made in that city, and extending back, with little interruption, through a period of 1903 years preceding that event. This would carry us back to at least 2234 years before the birth of Christ, or to about the time of the dispersion of mankind by the confusion of tongues. Though it be conceded, that upon this whole period in the history of the science, the obscurity of very remote antiquity must necessarily rest, still it will remain evident that the phenomena of the heavenly bodies had been observed with great attention, and had been a subject of no ordinary interest.

But however numerous or important were the observations of oriental antiquity, they were never reduced to the shape and symmetry of a regular system.

The Greeks, in all probability, derived many notions in regard to this science, and many facts and observations, from Egypt, the great fountain of ancient learning and wisdom, and many were the speculations and hypotheses of their philosophers. In the fabulous period of Grecian history, Atlas, Hercules, Linus, and Orpheus, are mentioned as persons distinguished for their knowledge of astronomy, and for the improvements which they made in the science. But in regard to this period, little is known with certainty, and it must be *considered*, as it is *termed*, fabulous.

The first of the Greek philosophers who taught Astronomy, was Thales, of Miletus. He flourished about 640 years before the Christian era. Then followed Anaximander, Anaximenes, Anaxagoras, Pythagoras, Plato. Some of the doctrines maintained by these philosophers were, that the Earth was round, that it had two motions, a diurnal motion on its axis, and an annual motion around the Sun, that the Sun was a globe of fire, that the Moon received her light from the Sun, that she was habitable, contained mountains, seas, &c.; that her eclipses were caused by the Earth's shadow, that the planets were not designed merely to adorn our heavens, that they were worlds of themselves, and that the fixed stars were centers of distant systems. Some of them, however, maintained, that the Earth was flat, and others, that, though round, it was at rest in the center of the universe.

When that distinguished school of philosophy was established at Alexandria, in Egypt, by the munificence of the

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* It is well known that the Chinese have, from time immemorial, considered Solar Eclipses and conjunctions of the planets, as prognostics of importance to the Empire, and that they have been predicted as a matter of State policy.

Give some instances. Were these facts, however, reduced to a science? Whence, is it probable, that the Greeks derived their first notions of astronomy? What is the name of the first of the Greek philosophers who taught astronomy? At what time did he flourish? What Greek philosophers after him taught upon the same subject? Mention some of the doctrines which they maintained.

sovereigns to whom that portion of Alexander's empire had fallen, astronomy received a new impulse. It was now, in the second century after Christ, that the first complete system or treatise of astronomy of which we have any knowledge, was formed. All before had been unconnected and incomplete. Ptolemy, with the opinions of all antiquity, and of all the philosophers who had preceded him, spread out before him, composed a work in thirteen books, called the Μεγαλη Συνταξις, or Great System. Rejecting the doctrine of Pythagoras, who taught that the Sun was the center of the universe, and that the Earth had a diurnal motion on its axis and an annual motion around the Sun, as contrary to the evidence of the senses, Ptolemy endeavored to account for the celestial phenomena, by supposing the Earth to be the center of the universe, and all the heavenly bodies to revolve around it. He seems to have entertained an idea, in regard to the supposition, that the Earth revolved on its axis, similar to one which some entertain even at the present day. "If," says he, "there were any motion of the Earth common to it and all other heavenly bodies, it would certainly precede them all by the excess of its mass being so great; and animals and a certain portion of heavy bodies would be left behind, riding upon the air, and the Earth itself would very soon be completely carried out of the heavens."

In explaining the celestial phenomena, however, upon his hypothesis, he met with a difficulty in the apparently stationary attitude and retrograde motions which he saw the planets sometimes have. To explain this, however, he supposed the planets to revolve in small circles which he called epicycles, which were, at the same time, carried around the Earth in larger circles, which he called deferents, or carrying circles. In following out his theory and applying it to the explanation of different phenomena, it became necessary to add new epicycles, and to have recourse to other expedients, until the system became unwieldy, cumbrous, and complicated. This theory, although astronomical observations continued to be made, and some distinguished astronomers appeared from time to time, was the prevailing theory until the middle of the 15th century. It was not, however, *always* received with implicit confidence; nor were its difficulties *always* entirely unappreciated.

Alphonso X., king of Castile, who flourished in the 13th century, when contemplating the doctrine of the epicycles, exclaimed, "Were the universe thus constructed, if the deity had called me to his councils at the creation of the world, I could have given him good advice." He did not, however, mean any impiety or irreverence, except what was directed against the system of Ptolemy.

About the middle of the 15th century, Copernicus, a native of Thorn in Prussia, conceiving a passionate attachment to the study of astronomy, quitted the profession of

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When was the first complete system of Astronomy written, and by whom? In how many books was it comprised, and what was the work called? What was the system of Ptolemy? *How did Ptolemy explain the stations and retrogradations of the planets? How long was the system of Ptolemy the prevailing system? Was it always received with implicit confidence?* Who established a new system of Astronomy about the middle of the 15th century?

medicine, and devoted himself with the most intense ardor to the study of this science. "His mind," it is said, "had long been imbued with the idea that simplicity and harmony should characterize the arrangements of the planetary system. In the complication and disorder which he saw reigned in the hypothesis of Ptolemy, he perceived insuperable objections to its being considered as a representation of nature."

In the opinions of the Egyptian sages, in those of Pythagoras, Philolaus, Aristarchus and Nicetas, he recognized his own earliest conviction that the Earth was not the center of the universe. His attention was much occupied with the speculation of Martinus Capella, who placed the Sun between Mars and the Moon, and made Mercury and Venus revolve round him as a center, and with the system of Appollonius Pergœus who made all the planets revolve around the Sun, while the Sun and Moon were carried around the Earth in the center of the universe.

The examination, however, of these hypotheses, gradually expelled the difficulties with which the subject was beset, and after the labor of more than thirty years, he was permitted to see the true system of the universe. The Sun he considered as immovable, in the center of the system, while the Earth revolved around him, between the orbits of Venus and Mars, and produced by its rotation about its axis all the diurnal phenomena of the celestial sphere. The other planets he considered as revolving about the Sun, in orbits exterior to that of the Earth. (*See the Relative Position of the Planets' Orbits, Plate I. of the Atlas.*)

Thus, the stations and retrogradations of the planets were the necessary consequence of their own motions, combined with that of the Earth about the Sun. He said that "by long observation, he discovered that, if the motions of the planets be compared with that of the Earth, and be estimated according to the times in which they perform their revolutions, not only their several appearances would follow from this hypothesis, but that it would so connect the order of the planets, their orbits, magnitudes, and distances, and even the apparent motion of the fixed stars, that it would be impossible to remove one of these bodies out of its place without disordering the rest, and even the whole of the universe also."

Soon after the death of Copernicus, arose Tycho Brahe,

What led him to doubt the system of Ptolemy? How long was he employed in the examination of different hypotheses before he came to a satisfactory result? What was the system of Copernicus? What distinguished astronomer, soon after the time of Copernicus, enriched astronomy with many valuable observations?

born at Knudstorp, in Norway, in 1546. Such was the distinction which he had attained as an astronomer, that when, dissatisfied with his residence in Denmark, he had resolved to remove, the King of Denmark, learning his intentions, detained him in the kingdom, by presenting him with the canonry of Rothschild, with an income of 2000 crowns per annum. He added to this sum a pension of 1000 crowns, gave him the island of Huen, and established for him an observatory at an expense of about 200,000 crowns. Here Tycho continued, for twenty-one years, to enrich astronomy with his observations. His observations upon the Moon were important, and upon the planets, numerous and precise, and have formed the data of the present generalizations in astronomy. He, however, rejected the system of Copernicus; considering the Earth as immovable in the center of the system, while the Sun, with all the planets and comets revolving around him, performed his revolution around the earth, and, in the course of twenty-four hours, the stars also revolved about the central body. This theory was not as simple as that of Copernicus, and involved the absurdity of making the Sun, planets, &c., revolve around a body comparatively insignificant.

Near the close of the 15th century, arose two men, who wrought most important changes in the science, Kepler and Galileo, the former a German, the latter an Italian.

Previous to Kepler, all investigations proceeded upon the supposition that the planets moved in circular orbits which had been a source of much error. This supposition Kepler showed to be false. He discovered that their orbits were ellipses. The orbits of their secondaries or moons he also found to be the same curve. He next determined the dimensions of the orbits of the planets, and found to what their velocities in their motions through their orbits, and the times of their revolutions, were proportioned; all truths of the greatest importance to the science.

While Kepler was making these discoveries of facts, very essential for the explanation of many phenomena, Galileo was discovering wonders in the heavens never before seen by the eye of man. Having improved the telescope, and applied it to the heavens, he observed mountains and valleys upon the surface of our Moon; satellites or secondaries

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What inducements did the king of Denmark offer him to remain in the kingdom? How long did he continue to make observations in his observatory in the island of Huen? How were the heavenly bodies arranged, in his system? What absurdity did it involve? What two illustrious astronomers made several very important discoveries soon after the time of Tycho Brahe? What were the discoveries of Kepler? What were the discoveries of Galileo?

were discovered revolving about Jupiter; and Venus, as Copernicus had predicted, was seen exhibiting all the different phases of the Moon, waxing and waning as she does, through various forms. Many minute stars, not visible to the naked eye, were descried in the Milky-Way; and the largest fixed stars, instead of being magnified, appeared to be small brilliant points, an incontrovertible argument in favor of their immense distance from us. All his discoveries served to confirm the Copernican theory, and to show the absurdity of the hypothesis of Ptolemy.

Although the general arrangement and motions of the planetary bodies, together with the figure of their orbits, had been thus determined, the force or power which carries them around in their orbits, was as yet unknown. The discovery of this was reserved for the illustrious Newton.* By reflecting on the nature of gravity—that power which causes bodies to descend toward the center of the earth—since it does not sensibly diminish at the greatest distance from the center of the earth to which we can attain, being as powerful on the loftiest mountains as it is in the deepest caverns, he was led to imagine that it might extend to the Moon, and that it might be the power which kept her in her orbit and caused her to revolve around the Earth. He was next led to suppose that perhaps the same power carried the primary planets around the Sun. By a series of calculations, he was enabled at length to establish the fact, that the same force which determines the fall of an apple to the Earth, carries the moons in their orbits around the planets, and the planets and comets in their orbits around the Sun.

To recapitulate briefly: The system (not hypothesis, for much of it has been established by mathematical demonstration) by which we are now enabled to explain with a beautiful simplicity the different phenomena of the Sun, planets, moons, and comets, is, that the Sun is the central body in the system: that the planets and comets move round him in elliptical orbits, whose planes are more or less inclined to each other, with velocities bearing to each other† a certain ascertained relation, and in times related to their distances; that the moons, or secondaries, revolve in like manner about their primaries, and at the same time accompany

* The discovery of Newton was in some measure anticipated by Copernicus, Kepler and Hooke.

† The orbits or paths of the planets were discovered by tracing the course of the planet by means of the fixed stars.

What was the discovery of Newton? How was he led to make it? Recapitulate briefly the system by which we are enabled to explain the different celestial phenomena.

them in their motion around the Sun; all meanwhile revolving on axes of their own; and that these revolutions in their orbits, are produced by the mysterious power of attraction. The particular mode in which this system is applied to the explanation of the different phenomena, will be exhibited as we proceed to consider, one by one, the several bodies above mentioned.

These bodies, thus arranged and thus revolving, constitute what is termed the solar system. The planets have been divided into two classes, primaries and secondaries. The latter are also termed moons, and sometimes satellites. The primaries are those which revolve about the Sun, as a center. The secondaries are those which revolve about the primaries. There have been discovered seventeen primaries; namely, Mercury, Venus, the Earth, Mars, Flora, Vesta, Iris, Metis, Hebe, Astrea, Juno, Ceres, Pallas, Jupiter, Saturn, Herschel, and Neptune. Mercury is the nearest to the Sun, and the others follow in the order in which they are named. The nine small planets from Flora to Pallas inclusive, were discovered by means of the telescope, and, because they are very small, compared with the others, are called asteroids. There have been discovered nineteen secondaries. Of these, the Earth has one, Jupiter four, Saturn seven, Herschel six, and Neptune one. All these, except our Moon, as well as the asteroids, are invisible to the naked eye.

Plate 1, of the Atlas, "exhibits a plan of the Solar System," comprising the relative magnitudes of the Sun and Planets; their comparative distances from the Sun, and from each other; the position of their orbits, with respect to each other; the Earth and the Sun; together with many other particulars which are explained on the map. There, the first and most prominent object which claims attention, is the representation of the Sun's circumference, with its deep radiations, bounding the upper margin of the map. It is apparent, however, that this segment is hardly *one-sixth* of the whole circumference of which it is a part. Were the map sufficiently large to admit the entire orb of the Sun, even upon so diminutive a scale as there represented, we should then see the Sun and Planets in their just proportions—the diameter of the former being 112 times the diameter of the Earth.

It was intended, originally, to represent the Earth upon a scale of *one inch* in diameter, and the other bodies in that proportion; but it was found that it would increase the map to four times its size; and hence it became necessary to assume a scale of *half* an inch for the Earth's diameter, which makes that of the Sun 56 inches, and the other bodies, as represented upon the map.

The relative position of the Planets' orbits is also represented, on a scale as large as the sheet would permit. Their relative distances from the Sun as a center, and from each other, are there shown correctly. But had we wished to enlarge the dimensions of these orbits, so that they would exactly correspond with the scale to which we have drawn the planets, the map must have been nearly four miles in length. "Hence," says Sir John Herschel, "the idea that

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What is meant by the Solar System? Into what two classes have the planets been divided? Define a primary planet. Define a secondary planet. How many primary planets have been discovered? What are their names, and what the order of their distance from the sun? Which of them were discovered by means of the telescope? Why are these termed asteroids? How many secondaries have been discovered? How are they distributed among the primaries? Which of the primaries and secondaries are invisible to the naked eye?

we can convey correct notions on this subject, by drawing circles on paper, is out of the question."

To illustrate this.—Let us suppose ourselves standing on an extended plane, or field of ice, and that a globe 4 feet 8 inches in diameter is placed in the center of the plane, to represent the Sun. Having cut out of the map the dark circles representing the planets. we may proceed to arrange them in their respective orbits about the Sun, as follows:

First, we should take Mercury, about the size of a small currant, and place it on the circumference of a circle 194 feet from the Sun; this circle would represent the orbit of Mercury, in the proper ratio of its magnitude. Next, we should take Venus, about the size of a rather small cherry, and place it on a circle 362 feet from the Sun, to represent the orbit of Venus. Then would come the Earth, about the size of a cherry, revolving in an orbit 500 feet from the Sun. After the Earth we should place Mars, about the size of a cranberry, on a circle 762 feet from the Sun. Neglecting the Asteroids, some of which would not be larger than a pin's head, we should place Jupiter, hardly equal to a moderate-sized melon, on a circle at the distance of half a mile (2601 feet) from the Sun; Saturn, somewhat less, on a circle nearly a mile (4769 feet) from the Sun; Herschel, about the size of a peach, on the circumference of a circle nearly 2 miles (9591 feet) from the Sun; and last of all Neptune, a little larger than Herschel, and on a circle of nearly 3 miles (15,366 feet) from the Sun.

To imitate the motions of the planets in the above-mentioned orbits, Mercury must describe its own diameter in 41 seconds; Venus, in 4 minutes 14 seconds; the Earth, in 7 minutes; Mars, in 4 minutes 48 seconds; Jupiter, in 2 hours 56 minutes; Saturn, in 3 hours 13 minutes; Herschel in 12 hours 16 minutes, and Neptune in 23 hours 25 minutes.

Many other interesting subjects are embraced in Plate 1; but they are either explained on the map, or in the following Chapters, to which they respectively relate.

CHAPTER XIX.

THE SUN.

The Sun is a vast globe, in the center of the solar system, dispensing light and heat to all the planets, and governing all their motions. It is the great parent of vegetable life, giving warmth to the seasons, and color to the landscape. Its rays are the cause of various phenomena on the surface of the earth and in the atmosphere. By their agency, all winds are produced, and the waters of the sea are made to circulate in vapor through the air, and irrigate the land, producing springs and rivers.

The Sun is by far the largest of the heavenly bodies whose dimensions have been definitely ascertained. Its diameter is about 887 thousand miles. Consequently, it contains a volume of matter equal to *fourteen hundred thousand globes* of the size of the Earth. Of a body so vast in its dimensions, the human mind, with all its efforts, can form no adequate conception.

Here let the student refer to Plate 1, where the Relative Magnitudes of the Sun and Planets are exhibited. Let him compare the segment of the Sun's circum

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Mention some of the effects produced by the Sun. What is its magnitude compared with that of the other heavenly bodies whose dimensions have been estimated? What is its diameter? How much larger is the Sun than the Earth?

ference, as there represented, with the entire circumference of the Earth. They are both drawn upon the same scale. The segment of the Sun's circumference, since it is almost a straight line, must be a very small part of what the whole circumference would be, were it represented entire. Let the student understand this diagram, and he will be in some measure able to conceive how like a mere point the Earth is, compared with the Sun, and to form in his mind some image of the vast magnitude of the latter.

Were the Sun a hollow sphere, perforated with a thousand openings to admit the twinkling of the luminous atmosphere around it—and were a globe as large as the Earth placed at its center, with a satellite as large as our Moon, and at the same distance from it as she is from the earth, there would be present to the eye of a spectator on the interior globe, a universe as splendid as that which now appears to the uninstructed eye—a universe as large and extensive as the whole creation was conceived to be, in the infancy of astronomy.

The mean distance of the Moon from the Earth is 240,000 miles, consequently the average diameter of her orbit is 480,000 miles; and yet, were the Sun to take the place of the Earth he would fill the whole orbit of the Moon, and extend 200,000 miles beyond it in every direction! To pass from side to side through his center, at rail-road speed (30 miles an hour), would require nearly three and a half years; and to traverse his vast circumference nearly eleven years.

The next thing which fills the mind with wonder, is the *distance* at which so great a body must be placed, to occupy, apparently, so small a space in the firmament. The Sun's mean distance from the Earth, is twelve thousand times the Earth's diameter, or a little more than 95 millions of miles. We may derive some faint conception of such a distance, by considering that the swiftest steamboats, which ply our waters at the rate of 200 miles a day, would not traverse it in *thirteen hundred years;* and, that a cannon ball, flying night and day, at the rate of 16 miles a minute, would not reach it in *eleven years.*

The Sun, when viewed through a telescope, presents the appearance of an enormous globe of fire, frequently in a state of violent agitation or ebullition; dark spots of irregular form, rarely visible to the naked eye, frequently pass over his disc, from east to west, in the period of nearly fourteen days.

These spots are usually surrounded by a penumbra, or

What is the whole distance between the Earth and the Moon, compared with the diameter of the Sun? Give some illustration to enable us to conceive of the magnitude of the Sun. What is the distance of the Sun from the Earth? Give some illustration to enable us to conceive of the distance. What is the appearance of the Sun when viewed through a telescope? In what time do the spots seen on the Sun pass across the disc? In what direction do they move? Describe their appearance.

less deeply shaded border, and that, by a margin of light, more brilliant than that of the Sun. A spot, when first seen on the eastern edge of the Sun, appears like a line which progressively extends in breadth, and increases its apparent velocity, till it reaches the middle, when it begins to contract, and to move less rapidly, till it ultimately disappears, at the western edge. In some rare instances, the same spots re-appear on the east side, and are permanent for two or three revolutions. But, as a general thing, the spots on the Sun are neither permanent nor uniform. Sometimes several small ones unite into a large one; and, again, a large one separates into numerous small ones. Some continue several days, weeks, and even months, together; while others appear and disappear, in the course of a few hours. Those spots that are formed gradually, are, for the most part, as gradually dissolved; whilst those that are suddenly formed, generally vanish as quickly.

It is the general opinion, that spots on the Sun were first discovered by Galileo, in the beginning of the year 1611; though Scheiner, Harriot, and Fabricius, observed them about the same time. During a period of 18 years from this time, the Sun was never found entirely clear of spots, excepting a few days in December, 1624; at other times, there were frequently seen twenty or thirty at a time, and in 1625, upwards of fifty were seen at once. From 1650 to 1670, scarcely any spots were to be seen; and, from 1676 to 1684, the orb of the Sun presented an unspotted disc. Since the beginning of the eighteenth century, scarcely a year has passed, in which spots have not been visible, and frequently in great numbers. In 1799, Dr. Herschel observed one nearly 30,000 miles in breadth.

A single second of angular measure, on the Sun's disc, as seen from the Earth, corresponds to 462 miles; and a circle of this diameter (containing therefore nearly 220,000 square miles) is the least space which can be distinctly discerned on the Sun as a *visible area*, even by the most powerful glasses. Spots have been observed, however, whose linear diameter has been more than 44,000 miles; and, if some records are to be trusted, of even still greater extent.

Dr. Dick, in a letter to the author, says: "I have for many years examined the solar spots with considerable minuteness, and have several times seen spots which were not less than the one twenty-fifth part of the Sun's diameter, which would make them about 22,192 miles in diameter, yet they were visible neither to the naked eye, nor through an opera glass, magnifying about three times. And, therefore, if any spots have been visible to the naked eye—which we must believe, unless we refuse respectable testimony—they could not have been much less than 50,000 miles in diameter."

The apparent direction of these spots over the Sun's disc, is continually varying. Sometimes they seem to move

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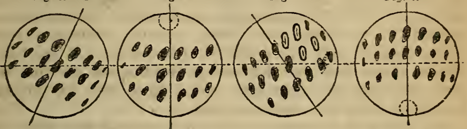
Do the same spots ever re-appear on the east side? Are the spots generally permanent and uniform? Describe their irregularities. Who is it generally supposed first discovered spots on the Sun? Who else observed them about the same time? What was the breadth of the one seen by Dr. Herschel in 1799? In what direction do the spots on the Sun appear to move?

across it in *straight* lines, at others in *curve* lines. Sometimes the spots seem to move *upward*, as they cross from east to west, while at other times they incline *downward*, while the curve lines are sometimes convex towards one pole of the Sun, and sometimes towards the other. All these phenomena are owing to the fact that the axis of the Sun is inclined to the Ecliptic, so that viewing him from different points in the Earth's orbit, the apparent direction of the spots must necessarily vary. The following diagrams may serve to illustrate:

Fig. 1. N　Fig. 2.　Fig. 3.　Fig. 4.



S December.　March.　June.　September.

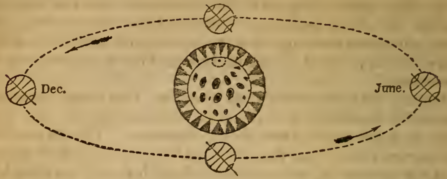
These figures are representations of the body of the Sun. The dotted horizontal line running through his center, is the plane of the Ecliptic. The lines N S, &c. represent the axis of the Sun, and his North and South poles. In November and December we have, so to speak, a *side view* of the axis of the Sun, his poles being equi-distant from us. At this time the spots, entering upon his left or eastern limb, incline *downward*, and pass over his disc in a direct line as at Fig. 1. Three months from this time, the Earth having advanced ninety degrees in her orbit, and the axis of the Sun remaining fixed, his North pole will be inclined towards us, and the spots will seem to pass over his surface in *curve lines*, as shown in Fig. 2. On the first of June the Earth is directly opposite the point from which we view the Sun in December, and his poles are again equi-distant from us. At this time the spots again revolve in *straight lines*, and seem to move *upward* over the Sun's disc as shown at Fig. 3. In September the South pole of the Sun is inclined towards the Earth, and the spots describe curve lines convex towards the North pole, as shown at Fig. 4.

The cut exhibits the penumbra, surrounding the more deeply shaded portion in the center of the spots, and illustrates the cause and progress of their apparent expansion as they approach the Sun's center, and their contraction as they recede from it.

The annexed cut, which can be understood without further

What causes the variations in their direction? How do the spots appear to move in December? March? June? September? Why do the spots appear larger as they approach the Sun's center? Do the spots revolve with regularity, or otherwise?

explanation, will serve to make this still more clear to the mind of the student.



From the regularity with which these spots revolve, it is concluded with good reason, that they adhere to the surface of the Sun and revolve with it. They are all found within 30° of his equator, or within a zone 60 in width.

The apparent revolution of a spot, from any particular point of the Sun's disc, to the same point again, is accomplished in 27 days, 7 hours, 26 minutes, and 24 seconds; but during that time, the spot has, in fact, gone through one revolution, together with an arc, equal to that described by the Sun, in his orbit, in the same time, which reduces the time of the Sun's actual rotation on his axis, to 25 days, 9 hours, and 36 minutes.

The part of the Sun's disc not occupied by spots, is far from being uniformly bright. Its *ground* is finely mottled with an appearance of minute, dark dots, or *pores*, which, attentively watched for several days in succession, are found to be in a constant state of change.*

What the physical organization of the Sun may be, is a question which astronomy, in its present state, cannot solve. It seems, however, to be surrounded by an ocean of inexhaustible flame, with dark spots of enormous size, now and then floating upon its surface. From these phenomena, Sir W. Herschel supposed the Sun to be a solid, dark body, surrounded by a vast atmosphere, almost always filled with luminous clouds, occasionally opening and disclosing the dark mass within. The speculations of Laplace were dif-

* See Journal of Observations on a Cluster of Spots upon the Sun's Disc, in the month of March, 1837. By E. P. Mason.

What conclusions have been drawn from these phenomena? What is the apparent time occupied by a spot in revolving from any particular point of the Sun's disc to the same point again? What is the actual time occupied by the revolution of the spot, and of course by the Sun on its axis? Have we been able to determine what the physical organization of the Sun is? What was the theory of Sir W. Herschel in regard to this subject?

ferent. He imagined the solar orb to be a mass of fire, and the violent effervescences and explosions seen on its surface, to be occasioned by the eruption of elastic fluids, formed in its interior, and the spots to be enormous caverns, like the craters of our volcanoes. Others have conjectured that these spots are the tops of solar mountains, which are sometimes left uncovered by the luminous fluid in which they are immersed.

Among all the conflicting theories that have been advanced, respecting the physical constitution of the Sun. there is none entirely free from objection. The *prevailing* one seems to be, that the lucid matter of the Sun is neither a liquid substance, nor an elastic fluid, but that it consists of luminous clouds, floating in the Sun's atmosphere, which extends to a great distance, and that these dark spots are the opaque body of the Sun, seen through the openings in his atmosphere. Herschel supposes that the density of the luminous clouds need not be greater than that of our Aurora Borealis, to produce the effects with which we are acquainted.

The similarity of the Sun, to the other globes of the system, in its supposed solidity, atmosphere, surface diversified with mountains and valleys, and rotation upon its axis, has led to the conjecture that it is inhabited, like the planets, by beings whose organs are adapted to their peculiar circumstances. Such was the opinion of the late Dr. Herschel, who observed it unremittingly, with the most powerful telescopes, for a period of fifteen years. Such, too, was the opinion of Dr. Elliot, who attributes to it the most delightful scenery; and, as the light of the Sun is eternal, so, he imagined, were its seasons. Hence he infers that this luminary offers one of the most blissful habitations for intelligent beings of which we can conceive.

MERCURY.

Mercury is the nearest planet to the Sun that has yet been discovered; and with the exception of the asteroids. is the smallest. Its diameter is only 3,140 miles. Its bulk therefore is about 16 times less than that of the Earth. It

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What was that of Laplace? What is the prevailing theory? What circumstances have led to the conjecture that the Sun is inhabited? What was the opinion of Dr. Herschel on this point? How long had he observed it unremittingly, and with the most powerful telescopes? What was the opinion of Dr. Elliot upon the same point? What is the distance of Mercury from the Sun? What is its magnitude compared with that of the other planets? What is its diameter?

would require more than 20 millions of such globes to compose a body equal to the Sun.

Here the student should refer to the diagrams, exhibiting the relative magnitudes and distances of the Sun and Planets, Plate I. And whenever this subject recurs in the course of this work, the student should recur to the figures of this plate, until he is able to form in his mind distinct conceptions of the relative magnitudes and distances of all the Planets. The Sun and Planets being spheres or nearly so, their relative bulks are estimated by comparing the cubes of their diameters: thus, the diameter of Mercury being 3140 miles, and that of the Earth 7912; their bulks are as the cube of 3140, to the cube of 7912, or as 1 to 16, nearly.

It revolves on its axis from west to east in 24 hours, 5 minutes, and 28 seconds; which makes its day about 10 minutes longer than ours. It performs its revolution about the Sun in a few minutes less than 88 days, and at a mean distance of nearly 37 millions of miles. The length of Mercury's year, therefore, is equal to about three of our months.

The rotation of a planet on its axis, constitutes its day; its revolution about the Sun constitutes its year.

Mercury is not only the most dense of all the planets, but receives from the Sun six and a half times as much light and heat as the Earth. The truth of this estimate, of course, depends upon the supposition that the intensity of solar light and heat at the planets, varies inversely as the squares of their distances from the Sun.

This law of analogy, did it exist with rigorous identity at all the planets, would be no argument against their being inhabited; because we are bound to presume that the All-wise Creator has attempered every dwelling-place in his empire to the physical constitution of the beings which he has placed in it.

From a variety of facts which have been observed in relation to the production of *caloric*, it does not appear probable, that the degree of heat on the surface of the different planets depends on their respective distances from the Sun. It is more probable, that it depends chiefly on the distribution of the *substance of caloric* on the surfaces, and throughout the atmospheres of these bodies, in different quantities, according to the different situations which they occupy in the solar system; and that these different quantities of caloric are put into action by the influence of the solar rays, so as to produce that degree of *sensible* heat requisite to the wants, and to the greatest benefit of each of the planets. On this hypothesis, which is corroborated by a great variety of facts and experiments, there may be no more sensible heat experienced on the planet Mercury, than on the surface of Herschel, which is fifty times farther removed from the Sun.

How many such bodies would it require to compose a body equal to the Sun? *How are the relative bulks of the planets estimated?* In what direction does it revolve on its axis, and what time does it occupy in the revolution? In how long time does it perform its revolution about the Sun? What is its mean distance from the Sun? What, then, is the length of its year compared with ours? *What measures a planet's day? What measures its year?* What is the density of Mercury, compared with that of the other planets? How much light and heat does it receive, compared with the Earth? On what supposition does the truth of this estimate depend? If this were really the fact in regard to the planets, would it be any argument against their being inhabited? *On what does the degree of heat at the different planets probably depend?* Why have astronomers been able to make but comparatively few discoveries respecting Mercury?

Owing to the dazzling brightness of Mercury, the swiftness of its motion, and its nearness to the Sun, astronomers have made but comparatively few discoveries respecting it. When viewed through a telescope of considerable magnifying power, it exhibits at different periods, all the various phases of the Moon; except that it never appears quite full, because its enlightened hemisphere is never turned directly towards the Earth, only when it is *behind* the Sun, or so near to it, as to be hidden by the splendor of its beams. Its enlightened hemisphere being thus always turned towards the Sun, and the opposite one being always dark, prove that it is an opaque body, similar to the Earth, shining only in the light which it receives from the Sun.

The rotation of Mercury on its axis, was determined from the daily position of its horns, by M. Schroeter, who not only discovered spots upon its surface, but several mountains in its southern hemisphere, one of which was 10¾ miles high—nearly three times as high as Chimborazo, in South America.

It is worthy of observation, that the highest mountains which have been discovered in Mercury, Venus, the Moon, and perhaps we may add the Earth, are all situated in their southern hemispheres.

During a few days in March and April, August and September, Mercury may be seen for several minutes, in the morning or evening twilight, when its greatest elongations happen in those months; in all other parts of its orbit, it is too near the Sun to be seen by the naked eye. The greatest distance that it ever departs from the Sun, on either side, varies from 16° 12′, to 28° 48′, *alternately*.

The distance of a planet from the Sun, as seen from the Earth, (measured in degrees,) is called its elongation. The greatest *absolute* distance of a planet from the Sun is denominated its *aphelion*, and the least its *perihelion*. On the diagram exhibiting the Relative Position of the Planets' Orbits, [Plate 1,] these points are represented by little dots in the orbits at the extremities of the right lines which meet them; the Perihelion points being above the Ecliptic, the Aphelion points below it.

The revolution of Mercury about the Sun, like that of all the planets, is performed from west to east, in an orbit which is nearly circular. Its *apparent* motion as seen from the earth, is, alternately, from west to east, and from east to west, nearly in straight lines; sometimes, directly across the face

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What is its appearance when viewed through a telescope of considerable magnifying power? What circumstances prove that it is an opaque body, shining only with the light of the Sun? How was the rotation of Mercury on its axis determined, and by whom? What did he discover on its surface? What was the altitude of the highest mountain which he saw? *In which hemisphere are the highest mountains which have been discovered in Mercury, Venus, and the Moon, situated. Does the same fact exist in regard to the Earth?* During what months may Mercury be seen for a few days, and in what parts of the day? Why is it visible at these times, and not at others? What are the greatest distances which it departs from the Sun on either side? *What is the Elongation of a planet? What is its Aphelion? What is its Perihelion?* In what direction does Mercury revolve about the Sun? What is the figure of its orbit? Describe its apparent motion, as seen from the Earth.

of the Sun, but at all other times, either a little above, or a little below it.

Being commonly immersed in the Sun's rays in the evening, and thus continuing invisible till it emerges from them in the morning, it appeared to the ancients like two distinct stars. A long series of observations was requisite, before they recognized the identity of the star which was seen to recede from the Sun in the morning with that which approached it in the evening. But as the one was never seen until the other disappeared, both were at last found to be the *same* planet, which thus oscillated on each side of the Sun.

Mercury's oscillation from west to east, or from east to west, is really accomplished in just half the time of its revolution, which is about 44 days; but as the Earth, in the mean time, follows the Sun in the same direction, the apparent elongations will be prolonged to between 55 and 65 days.

The passage of Mercury directly between the Earth and the Sun, and apparently over his disc, is called a *Transit.* This would occur at every revolution, if his orbit lay in the same plane with that of the Earth; but as it does not, but is inclined to the Earth's orbit, 7° 9′, and consequently cuts it at two opposite points in the Ecliptic; and as transits can occur only when Mercury is in the plane of the Earth's orbit, it follows that they can take place only occasionally; and when he is passing these two opposite points of his orbit. The following diagram will illustrate our meaning:

THE ECLIPTIC, NODES, TRANSITS, &C.

The horizontal circle represents the orbit of the Earth, in which she is seen at four different points. Within this circle is seen the orbit of Mercury, cutting or passing through the plane of the former at two opposite points called the *Nodes.* A N and D N mark the *ascending* and *descending* Nodes, as also the char-

How did it appear to the ancients? What was the cause of this appearance? How were these apparently two distinct stars at last found to be but one? What is the actual period of each elongation of Mercury? What the apparent period? What is the cause of this difference? What does the expression, transit of Mercury, signify? Why does it not make a transit at every revolution?

sects ☊ and ☋. L N. designates the *line of the Nodes*. Now it is obvious that if Mercury should be at his ☊ when the Earth is in ♉, and exactly on the line of the Nodes, as shown in the cut. the former would appear to pass like a dark spot, *upward* over the Sun's disc. On the other hand, should the two planets meet on the line of the Nodes at ☋, Mercury would appear to pass *downward* over the face of the Sun.

Again ; as these Node points are on opposite sides of the Ecliptic, and are passed by the Earth in May and November, it follows that all transits of Mercury must occur in one or the other of these months. They are, therefore called the *Node months.* As is shown in the diagram, the Earth passes the ascending Node of Mercury in November, and the descending in May ; the former of which is in the 16th degree of Taurus, and the latter in the 16th degree of Scorpio.

For the relative position of the planets' orbits, and their inclination to the plane of the Ecliptic, see Plate 1, of the Atlas. Here the dotted lines continued from the dark lines denote the inclination of the orbits to the plane of the Ecliptic, which inclination is marked in figures on them. Let the student fancy as many circular pieces of paper intersecting each other at the several angles of inclination marked on the Plate. and he will be enabled to understand more easily what is meant by the inclination of the planets' orbits.

The following is a list of all the Transits of Mercury from the time the first was observed by Gassendi, November 6. 1631, to the end of the present century.

1631 Nov. 6.	1707 May 5.	1776 Nov. 2.	1835 Nov. 7.
1644 Nov. 6.	1710 Nov. 6.	1782 Nov. 12.	1845 May 8.
1651 Nov. 2.	1723 Nov. 9.	1786 May 3.	1848 Nov. 9.
1661 May 3.	1736 Nov. 10.	1789 Nov. 5.	1861 Nov. 11.
1664 Nov. 4.	1740 Nov. 2.	1799 May 7.	1868 Nov. 4.
1674 May 6.	1743 Nov. 4.	1802 Nov. 8.	1878 May 6.
1677 Nov. 7.	1753 May 5.	1815 Nov. 11.	1881 Nov. 7.
1690 Nov. 9.	1756 Nov. 6.	1822 Nov. 4.	1891 May 9.
1697 Nov. 2.	1769 Nov. 9.	1832 May 5.	1894 Nov. 10.

By comparing the mean motion of any of the planets with the mean motion of the Earth, we may, in like manner, determine the periods in which these bodies will return to the same points of their orbit, and the same positions with respect to the Sun. The knowledge of these periods will enable us to determine the hour when the planets rise, set and pass the meridian, and in general, all the phenomena dependent upon the relative position of the Earth, the planet and the Sun; for at the end of one of these periods they commence again, and all recur in the same order. We have only to find a number of sidereal years, in which the planet completes exactly, or very nearly, a certain number of revolutions; that is, to find such a number of planetary revolutions, as, when taken together, shall be exactly equal to one, or any number of revolutions of the Earth. In the case of Mercury, this ratio will be as 87.969 is to 365.256. Whence we find that,

7 periodical revolutions of the Earth, are equal to 29 of Mercury :
13 periodical revolutions of the Earth, are equal to 54 of Mercury :
33 periodical revolutions of the Earth, are equal to 137 of Mercury :
46 periodical revolutions of the Earth, are equal to 191 of Mercury.

Therefore, transits of Mercury, at the same node, may happen at intervals of 7, 13, 33, 46, &c. years. Transits of Venus, as well as eclipses of the Sun and Moon, are calculated upon the same principle.

The *sidereal* revolution of a planet respects its *absolute* motion ; and is measured by the time the planet takes to revolve from any fixed star to the same star again.

The *synodical* revolution of a planet respects its *relative* motion ; and is measured by the time that a planet occupies in coming back to the same position with respect to the Earth and the Sun.

What are the points where the orbits of the planets intersect the orbit of the Earth called ? Where is Mercury's ascending node ? Where is its descending node ? In what months must the transit of Mercury occur for many ages to come ? Why must they occur in these months ? *How can we determine the periods in which the planets will return to the same points of their orbits, and the same positions in respect to the Sun ? Why is it useful to know these periods ? State the method of making the computation. What will the ratio be in the case of Mercury ? State the ratio between the periodical revolutions of the Earth and Mercury At what intervals, then, may transits of Mercury at the same node happen ? Upon what principle are transits of Venus and eclipses of the Sun and Moon calculated ? What is the sidereal revolution of a planet ? What is the synodical revolution ? What is the time of the sidereal revolution of Mercury ? State the method of computing the time of the synodical revolution. Compute the synodical revolution of Mercury.*

The sidereal revolution of Mercury, is 87d. 23h. 15m. 44s. Its *synodical* revolution is found by dividing the whole circumference of 360° by its *relative* motion in respect to the Earth. Thus, the mean daily motion of Mercury is 14732″.555; that of the Earth is 3548″.318; and their difference is 11184″.237, being Mercury's relative motion, or what it gains on the Earth every day. Now by simple proportion, 11184″.237 is to 1 day, as 360° is to 115d. 21h. 3′, 24″, the period of a synodical revolution of Mercury.

The *absolute* motion of Mercury in its orbit, is 109,757 miles an hour; that of the Earth, is 68,288 miles: the difference, 41,469 miles, is the mean *relative* motion of Mercury, with respect to the Earth.

VENUS.

There are but few persons who have not observed a beautiful star in the west, a little after sunset, called the *evening star*. This star is Venus. It is the second planet from the Sun. It is the brightest star in the firmament, and on this account easily distinguished from the other planets.

If we observe this planet for several days, we shall find that it does not remain constantly at the same distance from the Sun, but that it appears to approach, or recede from him, at the rate of about three-fifths of a degree every day; and that it is sometimes on the east side of him, and sometimes on the west, thus continually oscillating backwards and forwards between certain limits.

As Venus never departs quite 48° from tne Sun, it is never seen at midnight, nor in opposition to that luminary; being visible only about three hours after sunset, and as long before sunrise, according as its right ascension is greater or less than that of the Sun. At first, we behold it only a few minutes after sunset; the next evening we hardly discover any sensible change in its position; but after a few days, we perceive that it has fallen considerably behind the Sun, and that it continues to depart farther and farther from him, setting later and later every evening, until the distance between it and the Sun, is equal to a little more than half the space from the horizon to the zenith, or about 46°.

It now begins to return towards the Sun, making the same daily progress that it did in separating from him, and to set earlier and earlier every succeeding evening, until it finally sets with the Sun, and is lost in the splendor of his light.

What is the rate per hour of the absolute motion of Mercury in its orbit? Of the Earth? What is the mean relative motion of Mercury with respect to the Earth? What beautiful star sometimes appears in the west a little after sunset? What is the comparative distance of Venus from the Sun? What is its comparative brightness? In what direction is its apparent motion? Why is it never seen at midnight, nor in opposition to the Sun? At what times is it visible? How long after sunset is it when we first behold it in the west? Describe its changes of position.

A few days after the phenomena we have now described, we perceive, in the morning, near the eastern horizon, a bright star which was not visible before. This also is Venus, which is now called the *morning star*. It departs farther and farther from the Sun, rising a little earlier every day, until it is seen about 46° west of him, where it appears stationary for a few days; then it resumes its course towards the Sun, appearing later and later every morning, until it rises with the Sun, and we cease to behold it. In a few days, the evening star again appears in the west, very near the setting-sun, and the same phenomena are again exhibited. Such are the visible appearances of Venus.

Venus revolves about the Sun from west to east in $224\frac{2}{3}$ days, at the distance of about 68 millions of miles, moving in her orbit at the rate of 80 thousand miles an hour. She turns around on her axis once in 23 hours, 21 minutes, and 7 seconds. Thus her day is about 25 minutes shorter than ours, while her year is equal to $7\frac{1}{2}$ of our months, or 32 weeks.

The mean distance of the Earth from the Sun is estimated at 95 millions of miles, and that of Venus being 68 millions, the diameter of the Sun, as seen from Venus, will be to his diameter as seen from the Earth, as 95 to 68, and the surface of his disc as the square of 95 to the square of 68, that is, as 9025 to 4626, or as 2 to 1 nearly. The intensity of light and heat being inversely as the squares of their distances from the Sun, Venus receives twice as much light and heat as the Earth.

Her orbit is within the orbit of the Earth; for if it were not, she would be seen as often in opposition to the Sun, as in conjunction with him; but she was never seen rising in the east while the Sun was setting in the west. Nor was she ever seen in quadrature, or on the meridian, when the Sun was either rising or setting. Mercury being about 23° from the Sun, and Venus 46°, the orbit of Venus must be *outside* of the orbit of Mercury.

The *true* diameter of Venus is 7700 miles; but her *apparent* diameter and brightness are constantly varying, according to her distance from the Earth. When Venus and the Earth are on the same side of the Sun, her distance from the Earth is only 26 millions of miles; when they are

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In what direction, and in what time does Venus revolve about the Sun? What is her distance from the Sun? What is the rate per hour of her motion in her orbit? In what time does she revolve on her axis? How are the lengths of her day and year, compared with those of the Earth? How much larger does the Sun appear at Venus than he does at the Earth? How much more light and heat does she receive from him than the Earth? How much farther is Venus from the Sun than Mercury? On which side of the orbit of Mercury must her orbit be? What is her true diameter? In what proportion do her apparent diameter and brightness constantly vary? What is her distance from the Earth when they are both on the same side of the Sun?

on opposite sides of the Sun, her distance is 164 millions of miles. Were the whole of her enlightened hemisphere turned towards us, when she is nearest, she would exhibit a light and brilliancy twenty-five times greater than she generally does, and appear like a small brilliant moon; but, at that time, her dark hemisphere is turned towards the Earth.

When Venus approaches nearest to the Earth, her *apparent*, or observed diameter, is $61''.2$; when most remote, it is only $9''.6$: now $61''.2 \div 9''.6 = 6\frac{3}{8}$, hence when nearest the Earth her apparent diameter is $6\frac{3}{8}$ times greater than when most distant, and surface of her disc $(6\frac{3}{8})^2$, or nearly 41 times greater. In this work, the apparent size of the heavenly bodies is estimated from the apparent surface of their discs, which is always proportional to the squares of their apparent diameters.

When Venus' right ascension is less than that of the Sun, she rises before him; when greater, she appears after his setting. She continues alternately morning and evening star, for a period of 292 days, each time.

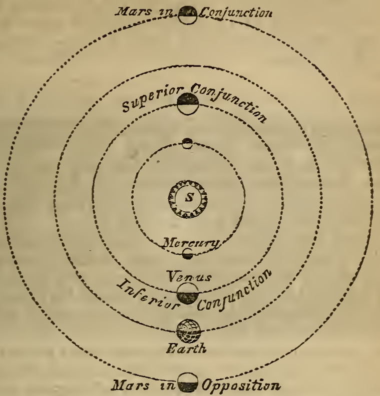
To those who are but little acquainted with astronomy, it will seem strange, at first, that Venus should apparently continue longer on the east or west side of the Sun, than the whole time of her periodical revolution around him. But it will be easily understood, when it is considered, that while Venus moves around the Sun, at the rate of about $1° 36'$ of angular motion per day, the Earth follows at the rate of $59'$; so that Venus actually gains on the Earth, only $37'$ in a day.

Now it is evident that both planets will appear to keep on the same side of the Sun, until Venus has gained half her orbit, or 180° in advance of the Earth; and this, at a mean rate, will require 292 days, since $292 \times 37' = 10804'$, or 180° nearly.

Mercury and Venus are called *Interior* planets, because their orbits are *within* the Earth's orbit, or between it and the Sun. The other planets are denominated *Exterior*, because their orbits are without or beyond the orbit of the Earth. [*Plate I.*] As the orbits of Mercury and Venus lie *within* the Earth's orbit, it is plain, that once in every synodical revolution, each of these planets will be in conjunction on the same side of the Sun. In the former case, the planet is said to be in its *inferior conjunction*, and in the latter case, in its *superior conjunction;* as in the following figure.

What is it when they are on opposite sides of the Sun? Which hemisphere is turned towards the Earth when she is nearest to us? Were her enlightened hemisphere turned towards us at that time, how would her light and brilliancy be compared with that which she generally exhibits, and what would be her appearance? *What is the length of her apparent diameter when she is nearest to the Earth? What is it when she is most remote? How is the apparent size of a heavenly body estimated in this work?* In what circumstances does Venus rise before, and in what set after, the Sun? How long does she continue, each time, alternately morning and evening star? Why does she appear longer on the east or west side of the Sun than the whole time of her periodical revolution around him? Why are Mercury and Venus called Interior planets? Why are the other planets termed Exterior planets?

CONJUNCTION AND OPPOSITION OF THE PLANETS.



The period of Venus' synodical revolution is found in the same manner as that of Mercury; namely, by dividing the whole circumference of her orbit by her mean *relative* motion in a day. Thus, Venus' *absolute* mean daily motion is 1° 36′ 7″.8, the Earth's is 59′ 8″.3, and their difference is 36′ 59″.5. Divide 360° by 36′ 59″.5, and it gives 583.920, or nearly 584 days for Venus' synodical revolution, or the period in which she is twice in conjunction with the Earth.

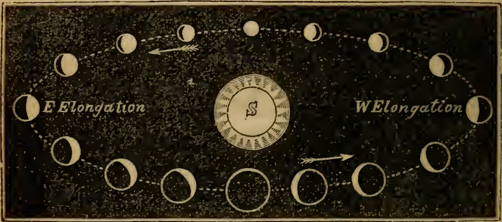
Venus passes from her inferior to her superior conjunction in about 292 days. At her inferior conjunction, she is 26 millions of miles from the Earth; at her superior conjunction, 164 millions of miles.

It might be expected that her brilliancy would be proportionally increased, in the one case, and diminished, in the other; and so it would be, were it not that her enlightened hemisphere is turned more and more from us, as she approaches the Earth, and comes more and more into view as she recedes from it. It is to this cause alone that we must attribute the uniformity of her splendor as it usually appears to the naked eye.

How often in every synodical revolution, will each of these planets be in conjunction on the same side of the Sun that the Earth is? How often on the opposite side? Explain this. What names distinguish these two species of conjunction? *How is the synodical revolution of Venus found? Make the calculation.* How long is she in passing from her inferior to her superior conjunction? How far is she from the Earth at her inferior conjunction How far at her superior? Why is not her brilliancy proportionably increased in the former case, and diminished in the latter? What appearances do Mercury and Venus present to us at different times?

Mercury and Venus present to us, successively, the various shapes and appearances of the Moon; waxing and waning through different phases, as shown in the following cut, from the beautiful crescent to the full rounded orb. This fact shows, that they revolve around the Sun, and between the Sun and the Earth.

PHASES OF VENUS AS SHE REVOLVES AROUND THE SUN



Let the pupil endeavor to explain these phases on any other supposition, and he will be convinced that the system of Ptolemy is erroneous, while that of Copernicus is confirmed.

It should be remarked, however, that Venus is never *seen* when she is entirely *full*, except once or twice in a century, when she passes directly over the Sun's disc. At every other conjunction, she is either *behind* the Sun, or so near him as to be hidden by the splendor of his light.* The preceding diagram better illustrates the various appearances of Venus, as she moves around the Sun, than any description of them could do.

From her inferior to her superior conjunction, Venus appears on the west side of the Sun, and is then our morning star; from her superior to her inferior conjunction she appears on the east side of the Sun, and is then our evening star.

These phenomena are illustrated by the diagram on the following page.

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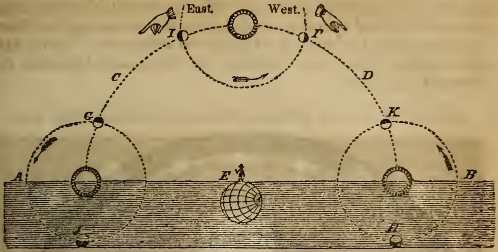
* The eminent astronomer. Thomas Dick, LL. D., well known in this country as the author of the Christian Philosopher, Philosophy of a Future State, &c., in a review of this remark, observes, "This ought not to be laid down as a general truth. About the year 1813, I made a great variety of observations on Venus in the day-time, by an equatorial instrument, and found that she could be seen when only 1° 27′ from the Sun's margin, and consequently *may* be seen at the moment of her superior conjunction, when her geocentric latitude, at that time, *equals* or *exceeds* 1° 43′. I have some faint expectations of being able to see Venus in the course of two or three days, at her superior conjunction, if the weather be favorable."—*March* 3, 1834.

What supposition is necessary for the explanation of these phases? What system do they tend to refute? What system do they confirm? *How often is Venus seen when she is entirely full? Why is she not seen at the full oftener?* In what part of her orbit does Venus appear on the west side of the Sun? In what on the east? In what parts is she alternately morning and evening star?

VENUS AS MORNING AND EVENING STAR.



Let the plane A B represent the sensible or visible horizon, C D the apparent daily path of the Sun through the heavens, and E the Earth in her apparent position. The Sun is seen at three points, namely, rising in the east, on the meridian, and setting in the west. Venus also is shown at each of these points, revolving around him from west to east, or in the direction of the arrows. Now it is obvious that when she is at F, or west of the Sun, she rises before the Sun as at G, and sets before him as at H. She is then *morning star*. On the other hand, when she is east of the Sun as at I, she rises after him as at J, and lingers after him when he sets, as at K. She is then *evening star*.

From this diagram the learner will also understand why it is that Venus can be seen with a telescope in the day-time, whether she be morning or evening star; and also why she appears to oscillate, first one side of the Sun and then the other. Were the diurnal motion of the Earth suspended so that the Sun could remain fixed upon the meridian, we could see Venus perform her entire journey around the Sun.

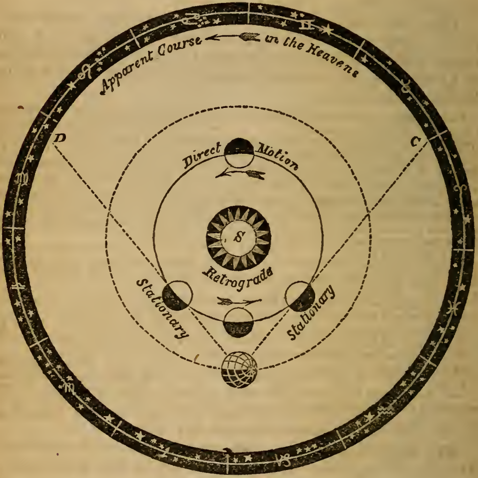
Like Mercury, she sometimes seems to be stationary. Her apparent motion, like his, is sometimes rapid; at one time, *direct*, and at another, *retrograde;* vibrating alternately backwards and forwards, from west to east, and from east to west. These vibrations appear to extend from 45° to 47°, on each side of the Sun.

Consequently she never appears in the eastern horizon, more than three hours before sunrise, nor continues longer in the western horizon, after sunset. Any star or planet, therefore, however brilliant it may appear, which is seen earlier or later than this cannot be Venus.

In passing from her western to her eastern elongation, her motion is from west to east, *in the order of the signs;* it is thence called *direct* motion. In passing from her eastern to her western elongation, her motion with respect to the Earth, is from east to west, *contrary* to the order of the signs; it is thence denominated *retrograde motion.* Her motion appears

Describe her apparent motion. How far on each side of the Sun do the vibrations of Venus extend? What is the direction of her motion while she passes from her western to her eastern elongation? Why is it called direct motion? What is its direction as she passes from her eastern to her western elongation? Why is it called retrograde quickest about the time of her conjunctions; and she seems stationary at her elongations. She is brightest about 36 days before and after her inferior conjunction, when her light is so great as to project a visible shadow in the night, and sometimes she may be seen with the naked eye even at noon-day.

DIRECT AND RETROGRADE MOTIONS OF THE PLANETS.



In the above cut Venus and the Earth may be seen in their respective orbits, revolving eastward around the Sun. The arrows indicate the direction. Beyond the orbits of the planets may be seen the concave circle of the starry heavens, and the constellations of the Zodiac. When Venus is at A, and has her greatest elongation earthward, her motion for a short time is almost always directly *towards* the Earth; so that she seems neither to recede from nor approach the Sun. She is then said to be *stationary*. While passing from A to B, her apparent motion is *retrograde*, that is, westward among the stars; at B she again seems to be stationary for a time.

From this point around to A again, her motion is *direct*, or eastward among the stars. She then seems to pass from C to D, as the arrow indicates her course through the heavens.

From this diagram the pupil will readily understand why her direct motion should continue much longer than her retrograde, &c.

When is her apparent motion quickest? When does she appear stationary? When is she brightest? How great is her light at this time?

If the orbit of Venus lay exactly in the plane of the Earth's orbit, she would pass centrally across the Sun's disc, like a dark round spot, at every inferior conjunction; but as one half of her orbit lies about 3⅓° above the ecliptic, and the other half as far below it, she will always pass the Sun a very little above or below it, except when her inferior conjunction happens in, or near, one of her nodes; in which case she will make a transit. [*See cut and explanations, page* 197, *and also Plate I., of Atlas.*

This phenomenon, therefore, is of very rare occurrence: it can happen only twice in a century; because it is only twice in that time that any number of complete revolutions of Venus, are just or nearly equal to a certain nnmber of the Earth's revolutions.

The principle which was illustrated in predicting the transits of Mercury, applies equally well to those of Venus; that is, we must find such sets of numbers, (representing complete revolutions of the Earth and Venus,) as shall be to each other in the ratio of their periodical times, or as 365.256 is to 224.7. Thus; the motion of Venus, in the Julian years, is 2106591''.52; that of the Earth for the same period being 129627''.45, the ratio will be $\frac{2106591''.52}{129627''.45}$. As the two terms of this fraction cannot be reduced by a common divisor, we must multiply them by such numbers as will make one a multiple of the other; accordingly, 13 times the denominator will be nearly equal to 8 times the numerator; and 475 times the denominator will equal 291 times the numerator.

By combining these two periods and their multiples by addition and subtraction, we shall obtain the period of all the transits that have ever happened. Thus; 291—8×7=235, another period; and 291—6×8 = 243, another period, and so on. Whence we find that.

8 periodical revolutions of the Earth, are equal to 13 of Venus.
235 periodical revolutions of the Earth, are equal to 382 of Venus.
243 periodical revolutions of the Earth, are equal to 395 of Venus.
251 periodical revolutions of the Earth, are equal to 408 of Venus.
291 periodical revolutions of the Earth, are equal to 475 of Venus.

Hence a transit of Venus may happen at the same node, after an interval of 8 years; but if it do not happen then, it cannot take place again at the same node, in less than 235 years. The orbit of Venus crosses the ecliptic near the middle of Gemini and Sagittarius; and these points mark the position of her nodes. At present, her ascending node is in the 14th degree of Gemini, and her descending node, in the same degree of Sagittarius.

The Earth passes her ascending node in the beginning of December, and her descending node, in the beginning of June. Hence, the transits of Venus, for ages to come, will happen in December and June. The first transit ever known to have been seen by any human being, took place at the ascending node, December 4th, 1639.* If to this date, we

* This phenomenon was first witnessed by Horrox, a young gentleman about 21 years of age, living in an obscure village 15 miles north of Liverpool. The tables of

Why does not Venus pass centrally across the Sun's disc at every inferior conjunction? In what circumstances will she make a transit across the Sun? How often can this phenomenon happen? Why can it not happen oftener? State the method of predicting the transits of Venus. *After how long an interval may a transit of Venus happen again at the same node? If it do not happen then, how long a period must elapse before it will occur again at the same node? Where does the orbit of Venus cross the ecliptic, and where are her nodes?* In what months, for ages to come, will the transits of Venus happen, and why? At which node, and when, did the first transit of Venus ever known to have been observed, take place?

add 235 years, we shall have the time of the next transit at the same node, which will accordingly happen in 1874. There will be another at the same node in 1882, eight years afterwards. It is not more certain that this phenomenon will recur, than that the event itself will engross the attention of all the astronomers then living upon the Earth. It will be anticipated, and provided for, and observed, in every inhabited quarter of the globe, with an intensity of solicitude which no natural phenomenon, since the creation, has ever excited.

The reason why a transit of Venus should excite so great an interest, is, because it may be expected to solve an important problem in astronomy, which has never yet been satisfactorily done:—a problem whose solution will make known to us the magnitudes and masses of all the planets, the true dimensions of their orbits, their rates of motion around the Sun, and their respective distances from the Sun, and from each other. It may be expected, in short, to furnish a universal standard of astronomical measure. Another consideration will render the observation of this transit peculiarly favorable; and that is, astronomers will be supplied with better instruments, and more accurate means of observation, than on any former occasion.

So important, says Sir John Herschel, have these observations appeared to astronomers, that at the last transit of Venus, in 1769, expeditions were fitted out, on the most efficient scale, by the British, French, Russian, and other governments to the remotest corners of the globe, for the express purpose of

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Kepler, constructed upon the observations of Tycho Brahe, indicated a transit of Venus in 1631, but none was observed. Horrox, without much assistance from books and instruments, set himself to inquire into the error of the tables, and found that such a phenomenon might be expected to happen in 1639. He repeated his calculations during this interval, with all the carefulness and enthusiasm of a scholar ambitious of being the first to predict and observe a celestial phenomenon, which, from the creation of the world, had never been witnessed! Confident of the result, he communicated his expected triumph to a confidential friend residing in Manchester, and desired him to watch for the event, and to take observations. So anxious was Horrox not to fail of witnessing it himself, that he commenced his observations the day before it was expected, and resumed them at the rising of the Sun on the morrow. But the *very hour* when his calculations led him to expect the visible appearance of Venus on the Sun's disc, *was also the appointed hour for the public worship of God on the Sabbath.* The delay of a few minutes might deprive him forever of an opportunity of observing the transit. If its very commencement were not noticed, clouds might intervene, and conceal it until the Sun should set: and nearly a century and a half would elapse before another opportunity would occur. He had been waiting for the event with the most ardent anticipation for eight years, and the result promised much benefit to the science. *Notwithstanding all this, Horrox twice suspended his observations, and twice repaired to the house of God,* the Great Author of the bright works he delighted to contemplate. When his duty was thus performed, and he had returned to his chamber the second time, his love of science was gratified with full success; and he saw what no mortal eye had observed before!

If any thing can add interest to this incident, it is the modesty with which the young astronomer apologizes to the world, for *suspending* his observations at all.

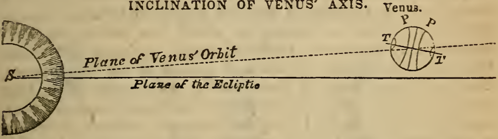
"I observed it," says he, "from sunrise till nine o'clock, again a little before ten, and lastly at noon, and from one to two o'clock; the rest of the day being devoted to higher duties, which might not be neglected for these pastimes."

When will the two next transits occur? Why will the next transit excite a very great and universal interest? Upon what do the phenomena of the seasons of each of the planets depend? What is the estimated inclination of the axis of Venus to the plane of her orbit?

making them. The celebrated expedition of Captain Cook to Otaheite, was one of them. The general result of all the observations made on this most memorable occasion, gives 8″.5776 for the Sun's horizontal parallax.

The phenomena of the seasons of each of the planets, like those of the Earth, depend upon the inclination of the axis of the planet to the plane of its orbit, and its revolution around the sun. The inclination of the axis of Venus to the plane of her orbit, though not precisely known, is commonly estimated at 75°, as represented to the eye in the following cut:

INCLINATION OF VENUS' AXIS.



This is more than three times as great as the inclination of the Earth's axis to the plane of the ecliptic.

The declination of the Sun on each side of her equator, must be equal to the inclination of her axis; and if this extends to 75°, her tropics T,T, are only 15° from her poles, and her polar circles P,P, only 15° from her equator. It follows, also, that the Sun must change his declination more in one day at Venus, than in five days on the Earth; and consequently, that he never shines vertically on the same places for two days in succession. This may perhaps be providentially ordered, to prevent the too great effect of the Sun's heat, which, on the supposition that it is in inverse proportion to the square of the distance, is twice as great on this planet as it is on the Earth.

At each pole, the Sun continues half a year* without setting in summer, and as long without rising in winter; consequently, the polar inhabitants of Venus, like those of the Earth, have only one day and one night in the year; with this difference, that the polar days and nights of Venus are not quite two-thirds as long as ours.

Between her polar circles, which are but 15° from her equator, there are two winters, two summers, two springs,

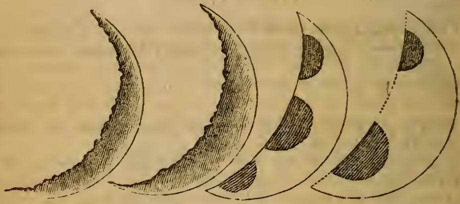
* That is, half of Venus' year, or 16 weeks.

How does this inclination compare with that of the Earth's axis to the plane of the ecliptic? What seasons have the northern parts of Venus, when those of the Earth have winter? How do we know this? To what must the declination of the Sun on each side of her equator be equal? How far are her tropics from her poles, and her polar circles from her equator? How much more must the Sun change his declination in one day at Venus than on the Earth? Why, perhaps, is this so ordered? How many days and nights have her polar inhabitants during the year? How long are these days and nights, compared with those of our polar inhabitants? How many, and what seasons, has Venus between her polar circles?

and two autumns, every year. But because the Sun stays for some time near the tropics, and passes so quickly over the equator, the winters in that zone will be almost twice as long as the summers.

The north pole of Venus' axis inclines towards the 20th degree of Aquarius; the Earth's towards the beginning of Cancer; consequently, the northern parts of Venus have summer in the signs where those of the Earth have winter, and vice versa.

TELESCOPIC APPEARANCES OF VENUS.



When viewed through a good telescope, Venus exhibits not only all the moon-like phases of Mercury, but also a variety of inequalities on her surface; dark spots, and brilliant shades, hills, and valleys, and elevated mountains. But on account of the great density of her atmosphere, these inequalities are perceived with more difficulty than those upon the other planets.

The mountains of Venus, like those of Mercury and the Moon, are highest in the southern hemisphere. According to M. Schroeter, a celebrated German astronomer, who spent more than ten years in observations upon this planet, some of her mountains rise to the enormous height of from 10 to 22 miles.* The observations of Dr. Herschel do not indicate so great an altitude; and he thinks, that in general they are considerably overrated. He estimates the diameter of Venus at 8,649 miles; making her bulk more than one sixth larger than that of the Earth. Several eminent as-

* 1st, 22.05 miles; 2d, 18.97 miles; 3d, 11.44 miles; 4th, 10.84 miles.

What is the length of the winters in this zone, compared with that of the summers? What appearances, besides her moon-like phases, does Venus exhibit when seen through a good telescope? Why is it more difficult to perceive the inequalities on her surface than those on the other planets? In which hemisphere are her mountains highest? What does M. Schroeter make the altitude of some of the highest? Is this estimate confirmed by the observations of Dr Herschel? How long is the diameter of Venus, according to Herschel's estimate? How much larger, then, must she be than the Earth?

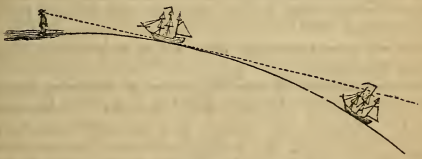
tronomers affirm, that they have repeatedly seen Venus attended by a satellite, and they have given circumstantial details of its size and appearance, its periodical revolution and its distance from her. It is said to resemble our Moon in its phases, its distance, and its magnitude. Other astronomers deny the existence of such a body, because it was not seen with Venus on the Sun's disc, at the transits of 1761 and 1769.

THE EARTH.

The Earth is the place from which all our observations of the heavenly bodies must necessarily be made. The apparent motions of these bodies being very considerably affected by her figure, motions, and dimensions, these hold an important place in astronomical science. It will therefore be proper to consider, first, some of the methods by which they have been determined.

If, standing on the sea-shore, in a clear day, we view a ship leaving the coast, *in any direction*, the hull or body of the vessel first disappears; afterwards the rigging, and lastly the top of the mast vanishes from our sight.

CONVEXITY OF THE EARTH.



Those on board the ship, observe that the coast first sinks below the horizon, then the buildings, and lastly the tallest spires of the city which they are leaving. Now these phenomena are evidently caused by the convexity of the water which is between the eye and the object; for, were the surface of the sea merely an extended plane, the largest objects would be visible the longest, and the smallest disappear first.

Another proof of the convexity of the earth's surface is, that the higher the eye is raised, the farther is the view extended. An observer may see the setting sun from the top

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Some astronomers affirm that they have seen Venus attended by a satellite, why do others deny the existence of such a body? Why is it important, in an astronomical view, to be acquainted with the figure, dimensions, and motions of the Earth? Mention some of the proofs of the convexity of its surface? *Who first sailed around the Earth?*

of a house, or any considerable eminence, after he has ceased to be visible to those below.

Again: navigators have sailed quite around the Earth, and thus proved its convexity.

CONVEXITY OF THE EARTH'S SURFACE.

Ferdinand Magellan, a Portuguese, was the first who carried this enterprise into execution. He embarked from Seville, in Spain, and directed his course towards the west. After a long voyage, he descried the continent of America. Not finding an opening to enable him to continue his course in a westerly direction, he sailed along the coast towards the south, till, coming to its southern extremity, he sailed around it, and found himself in the great Southern Ocean. He then resumed his course towards the west. After some time he arrived at the Molucca Islands, in the *Eastern Hemisphere;* and sailing continually towards the west, he made Europe from the east; arriving at the place from which he set out.*

The next who circumnavigated the Earth, was Sir Francis Drake, who sailed from Plymouth, December 13, 1577, with five small vessels, and arrived at the same place, September 26, 1580. Since that time, the circumnavigation of the Earth has been performed by Cavendish, Cordes, Noort, Sharten, Heremites, Dampier, Woodes, Rogers, Schovten, Roggewin, Lord Anson, Byron, Carteret, Wallis, Bougainville, Cook, King, Clerk, Vancouver, and many others.

These navigators, by sailing in a westerly direction, allowance being made for promontories, &c., arrived at the country they sailed from. Hence the Earth must be either cylindrical or globular. It cannot be cylindrical, because, if so, the meridian distances would all be equal to each other, which is contrary to observation. The figure of the Earth is, therefore, spherical.

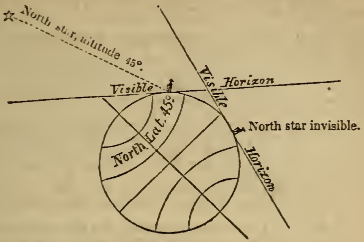
The convexity of the Earth, north and south, is proved by the variation in the altitude of the pole, and of the circumpo-

* Magellan sailed from Seville, in Spain, August 10, 1519, in the ship called the Victory, accompanied by four other vessels. In April, 1521, he was killed in a skirmish with the natives, at the island of *Sebu*, or *Zebu*, sometimes called Matan, one of the Philippines. One of his vessels, however, arrived at St. Lucar, near Seville, September 7, 1522.

Describe briefly his voyage. Who next circumnavigated the Earth? Describe his voyage? Mention the names of some of those who have since accomplished this enterprise. What may we infer from these facts in regard to the figure of the Earth?

lar stars, this is found uniformly to increase as we approach them, and to diminish as we recede from them.

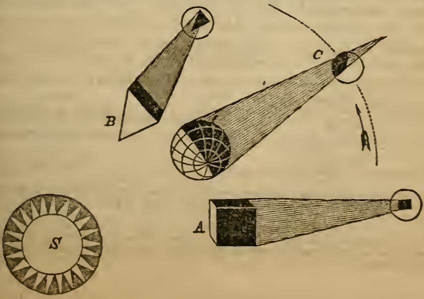
LATITUDE FOUND BY THE NORTH STAR.



Suppose an observer standing upon the Earth, and viewing the pole star from the 45° of North latitude; it would of course appear elevated 45° above his visible horizon. But let him recede southward, and as he passed over a degree of latitude, the pole star would settle one degree towards the horizon, or more properly, his northern horizon would be elevated one degree towards the pole star, till at length, as he crossed the equator, the North star would sink below the horizon, and become invisible. Whence we derive the general rule, that *the altitude of one pole, or the depression of the other, at any place on the Earth's surface, is equal to the latitude of that place.*

The form of the Earth's shadow, as seen upon the Moon in an eclipse, indicates the globular figure of the earth, and the consequent convexity of its surface.

FORM OF THE EARTH'S SHADOW.



Were the Earth a *cube*, as shown at A, or in the form of a *prism*, as represented at B, her shadow would be more or less cubical or prismatic, as seen in the cut; but instead of this, it is *convex on all sides*, as represented at C, plainly indicating the convexity of the Earth by which it is caused.

The curvature of the Earth for one mile is 8 inches; and this curvature increases with the square of the distance. From this general law it will be easy to calculate the distance at which any object whose height is given, may be seen, or to determine the height of an object when the distance is known.

1st. To find the height of the object when the distance is given.

RULE. *Find the square of the distance in miles, and take two-thirds of that number for the height in feet.*

Ex. 1.—How high must the eye of an observer be raised, to see the surface of the ocean, at the distance of three miles? *Ans.* The square of 3 ft. is 9 ft., and ⅔ of 9 ft. is 6 ft. Ex. 2.—Suppose a person can just see the top of a spire over an extended plain of ten miles, how high is the steeple? *Ans.* The square of 10 is 100, and ⅔ of 100 is 66⅔, feet.

2. To find the distance when the height is given.

RULE. *Increase the height in feet one half, and extract the square root, for the distance, in miles.*

Ex. 1.—How far can a person see the surface of a plain, whose eye is elevated six feet above it? *Ans.* 6, i[illegible]ased by its half, is 9, and the square root of 9 is 3; the distance is then 3 m[illegible] Ex. 2.—To what distance can a person see a light-house whose height is 96 feet from the level of the ocean? *Ans.* 96 increased by its half, is 144, and the square root of 144, is 12; the distance is therefore 12 miles.

3. To find the curvature of the Earth when it exceeds a mile.

RULE. *Multiply the square of the distance by* .000126.

Although it appears from the preceding facts, that the Earth is spherical, yet it is not a perfect sphere. If it were, the length of the degrees of latitude, from the equator to the poles, would be uniformly the same; but it has been found, by the most careful measurement, that as we go from the equator towards the poles, the length *increases with the latitude.*

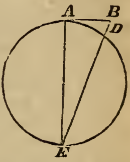
These measurements have been made by the most eminent mathematicians of different countries, and in various places, from the equator to the arctic circle. They have found that a degree of latitude at the arctic circle was *nine sixteenths* of a mile longer than a degree at the equator, and that the ratio of increase for the intermediate degrees was nearly as the squares of the sines of the latitude. Thus the theory of Sir Isaac Newton was confirmed, that the body of the Earth was more rounded and convex between the tropics, but considerably flattened towards the poles.

Places of Observation.	*Latitude.*	*Length of a degree in English miles.*	*Observers.*
Peru	Equator.	68.732	Bouguer,
Pennsylvania	39° 12′ N.	68.896	Mason and Dixon,
Italy	43 01	68.998	Boscovich and Lemaire,
France	46	69.054	Delambre and Mechain,
England	51 29′ 54.″	69.146	Mudge,
Sweden	66 20 10	69.292	Swamberg.

How is the convexity of her surface proved? *To what is the convexity proportional? State the rule, deduced from this fact, for finding the height of an object, when its distance from us is given. State the rule for finding the distance when the height is given. State the rule for finding the curvature of the Earth when the distance exceeds a mile.* Is the figure of the Earth an exact sphere? Were the Earth a perfect sphere, how would the length of the degrees of latitude be, compared with each other? How are tehy, in fact?

These measurements prove the Earth to be an *oblate spheroid*, whose longest or equatorial diameter is 7924 miles, and polar diameter, 7898 miles. The mean diameter is, therefore, about 7912, and their difference 26 miles. The French Academy have determined that the mean diameter of the Earth, from the 45th degree of north latitude, to the opposite degree of south latitude, is *accurately* 7912 miles.

If the earth were an exact sphere, its diameter might be determined by its curvature, from a single measurement. Thus, in the adjoining figure, we have A B equal to 1 mile, and B D equal to 8 inches, to find A E, or B E, which does not sensibly differ from A E, since B D is only 8 inches. Now it is a proposition of Euclid, (B. 3, prop. 36,) that, when from a point without a circle, two lines be drawn, one cutting and the other touching it, the touching line (B A) is a mean proportional between the cutting line (B E) and that part of it (B D) without the circle.



B D : B A : : B E or A E very nearly.

That is, 1 mile being equal to 63360 inches,

8 : 43360 : : 63360 : 50181120 inches, or 7920 miles.

This is very nearly what the most elaborate calculations make the Earth's equatorial diameter.

The Earth, considered as a planet, occupies a favored rank in the Solar System. It pleased the All-wise Creator to assign its position among the heavenly bodies, where nearly all the sister planets are visible to the naked eye. It is situated next to Venus, and is the third planet from the Sun.

To the scholar who for the first time takes up a book on astronomy, it will no doubt seem strange to find the Earth classed with the heavenly bodies. For what can appear more unlike, than the Earth, with her vast and seemingly immeasurable extent, and the stars, which appear but as points? The Earth is dark and opaque, the celestial bodies are brilliant. We perceive in it no motion; while in them we observe a continual change of place, as we view them at different hours of the day or night, or at different seasons of the year.

It moves round the Sun, from west to east, in 365 days 5 hours, 48 minutes, and 48 seconds; and turns, the same way, on its axis, in 23 hours, 56 minutes, and 4 seconds. The former is called its *annual* motion, and causes the vicissitudes of the seasons. The latter is called its *diurnal* motion, and produces the succession of day and night.

The Earth's mean distance from the Sun is about 95 millions of miles. It consequently moves in its orbit at the mean

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What is the length of a degree at the Arctic circle, compared with a degree at the equator, as found by the measurement of different mathematicians? What have they found to be the ratio of increase for the intermediate degrees? What theory do these facts confirm? What is the length of the Earth's equatorial diameter, as found by these measurements? What, her polar diameter? What is the difference between the two? What is her mean diameter? What have the French academy determined to be the exact mean diameter from the 45th degree of north latitude to the opposite degree of south latitude? *Illustrate the method of finding the diameter of the Earth from her curvature, on the supposition that her figure is an exact sphere. What is the length of her diameter as thus found? How is this, compared with the equatorial diameter, as found by the most elaborate calculations?* What is the position of the Earth in the Solar System? What revolutions does it perform, and in what direction? What is the time occupied in each of these revolutions? By what terms are these revolutions distinguished, and what important effects do they produce?

rate of 68 thousand miles an hour. Its equatorial diameter being 7924 miles, it turns on its axis at the rate of 1040 miles an hour.

Thus, the Earth on which we stand, and which has served for ages as the unshaken foundation of the firmest structures, is every moment turning swiftly on its center, and, at the same time, moving onwards with great rapidity through the empty space.

This compound motion is to be understood of the *whole Earth*, with all that it holds within its substance, or sustains upon its surface—of the solid mass beneath, of the ocean which flows around it, of the air that rests upon it, and of the clouds which float above it in the air.

That the Earth, in common with all the planets, revolves around the Sun as a center, is a fact which rests upon the clearest demonstrations of philosophy. That it revolves, like them, upon its own axis, is a truth which every rising and setting sun illustrates, and which very many phenomena concur to establish.

Either the Earth moves around its axis every day, or *the whole universe* moves around it in the same time. There is no third opinion, that can be formed on this point. Either the Earth must revolve on its axis every 24 hours, to produce the alternate succession of day and night, or the Sun, Moon, planets, comets, fixed stars, and the whole frame of the universe itself, must move around the Earth, in the same time. To suppose the latter case to be the fact, would be to cast a reflection on the wisdom of the Supreme Architect, whose laws are universal harmony. As well might the beetle, that in a moment turns on its ball, imagine the heavens and the earth had made a revolution in the same instant. It is evident, that in proportion to the distance of the celestial bodies from the Earth, must, on this supposition, be the rapidity of their movements. The Sun, then, would move at the rate of more than four hundred thousand miles in a minute; the nearest stars, at the inconceivable velocity of 1400 millions of miles in a *second;* and the most distant luminaries, with a degree of swiftness which no numbers could express, and all this, to save the litlte globe we tread upon, from turning safely on its axis once in 24 hours.

The idea of the heavens revolving about the Earth, is encumbered with innumerable other difficulties. We will mention only one more. It is estimated on good authority, that there are visible, by means of glasses, no less than one *hun-*

What is the Earth's mean distance from the Sun? What is the mean rate of its motion in its orbit per hour? What is the rate of its revolution on its axis per hour? What are the proofs, that it performs these two revolutions?

dred millions of stars, scattered at all possible distances in the heavens above, beneath, and around us. Now, is it in the least degree probable, that the velocities of all these bodies should be so regulated, that, though describing circles so very different in dimensions, they should complete their revolutions in exactly the same time?

In short, there is no more reason to suppose that the heavens revolve around the Earth, than there is to suppose that they revolve around each of the other planets, separately, and at the same time; since the same apparent revolution is common to them all, for they all appear to revolve upon their axes, in different periods.

The rotation of the Earth determines the length of the day, and may be regarded as one of the most important elements in astronomical science. It serves as a universal measure of time, and forms the standard of comparison for the revolutions of the celestial bodies, for all ages, past and to come. Theory and observation concur in proving, that among the innumerable vicissitudes that prevail throughout creation, the period of the Earth's diurnal rotation is immutable.

The Earth performs one complete revolution on its axis in 23 hours, 56 minutes, and 4.09 seconds, of solar time. This is called a *sidereal day*, because, in that time, the stars appear to complete one revolution around the Earth.

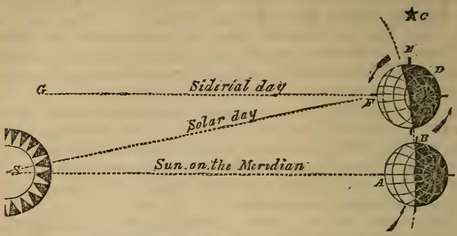
But, as the Earth advances almost a degree eastward in its orbit, in the time that it turns eastward around its axis, it is plain that just one rotation never brings the same meridian around from the Sun to the Sun again; so that the Earth requires as much more than one complete revolution on its axis to complete a *solar day*, as it has gone forward in that time.

The diagram in the following page will explain the difference between a solar and a sidereal revolution of the Earth.

SOLAR AND SIDEREAL DAYS.

The projections from the Earth's surface at four different points, indicate four meridians 90° apart. At A one is seen directly under the Sun, so that his light strikes it perpendicularly. At the same time the meridian B, is directly under or opposite the star C. But the Earth advances from this point to D, and at the same time revolves upon its axis till the meridian B again comes round opposite the *star*, as shown at E. At this time, however, the meridian A or F

What important purposes does the period of the Earth's rotation serve? What is a sidereal day? What is a solar day?



is not yet opposite the Sun, but opposite the point G, just as much *west* of the Sun, as the Earth has gone *eastward* in her orbit. It is obvious, therefore, that in every natural or solar day, the Earth performs one complete revolution on its axis, and the 365th part of another revolution. Consequently, in 365 days, the Earth turns 366 times around its axis. And as every revolution of the Earth on its axis completes a sidereal day, there must be 366 sidereal days in a year. And, generally, since the rotation of any planet about its axis is the length of a sidereal day at that planet, the number of sidereal days will always exceed the number of solar days, by one, let that number be what it may, one revolution being always lost in the course of an annual revolution. This difference between the sidereal and solar days may be illustrated by referring to a watch or clock. When both hands set out together, at 12 o'clock for instance, the minute hand must travel more than a whole circle before it will overtake the hour hand, that is, before they will come into conjunction again.

In the same manner, if a man travel around the Earth *eastwardly*, no matter in what time, he will reckon *one day more*, on his arrival at the place whence he set out, than they do who remain at rest; while the man who travels around the Earth *westwardly* will have *one day less*. From which it is manifest, that, if two persons start from the same place at the same time, but go in contrary directions, the one traveling eastward and the other westward, and each goes completely around the globe, although they should both arrive again at the very same hour at the same place from

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What part of a second revolution does the Earth complete in every solar day? How many times, then, does it turn on its axis in 365 days? How many sidereal days are there in a year? On any planet, what is the number of the sidereal days compared with the number of the solar? Illustrate the difference between the sidereal and solar days by referring to a watch or clock. Illustrate it by referring to two travelers going around the globe, one eastwardly and the other westwardly.

which they set out, yet they will disagree two whole days in their reckoning. Should the day of their return, to the man who traveled westwardly, be Monday, to the man who traveled eastwardly, it would be Wednesday; while to those who remained at the place itself, it would be Tuesday.

Nor is it necessary, in order to produce the gain or loss of a day, that the journey be performed either on the equator, or on any parallel of latitude; it is sufficient for the purpose, that all the meridians of the Earth be passed through, eastward or westward. The time, also, occupied in the journey, is equally unimportant; the gain or loss of a day being the same, whether the Earth be traveled around in 24 years, or in as many hours.

It is also evident, that if the Earth turned around its axis but once in a year, and if the revolution was performed the same way as its revolution around the Sun, there would be perpetual day on one side of it, and perpetual night on the other.

From these facts the pupil will readily comprehend the principles involved in a curious problem which appeared a few years ago: It was gravely reported by an American ship, that, in sailing over the ocean, it chanced to find *six Sundays in February.* The *fact* was insisted on, and a solution demanded. There is nothing absurd in this.—The man who travels around the Earth *eastwardly*, will see the Sun go down a little earlier every succeeding day, than if he had remained at rest; or earlier than they do who live at the place from which he set out. The faster he travels towards the rising sun, the sooner will it appear above the horizon in the morning, and so much sooner will it set in the evening. What he thus gains in *time*, will bear the same proportion to a solar day, as the distance traveled does to the circumference of the Earth.—As the globe is 360 degrees in circumference, the Sun will appear to move over one twenty-fourth part of its surface, or 14°, every hour, which is 4 minutes to *one degree.*—Consequently, the Sun will rise, come to the meridian, and set, 4 minutes sooner, at a place 1° east of us, than it will with us; at the distance of 2° the Sun will rise and set 8 minutes sooner; at the distance of 3°, 12 minutes sooner, and so on.

Now the man who travels one degree to the east, the first day will have the Sun on his meridian 4 minutes sooner than we do who are at rest; and the second day 8 minutes sooner, and on the third day, 12 minutes sooner, and so on; each successive day being completed 4 minutes earlier than the preceding, until he arrives again at the place from which he started: when this continual gain of 4 minutes a day will have amounted to a whole day *in advance* of our time; he having seen the Sun rise and set *once more* than we have. Consequently, the day on which he arrives at home, whatever day of the week it may be, is one day in advance of ours, and he must needs live that day over again, by calling the next day by the same name, in order to make the accounts harmonize.

If this should be the last day of February in a bissextile year, it would also be the same day of the week that the *first* was, and be six times repeated, and if it should happen on Sunday, he would, under these circumstances, have six Sundays in February.

Again:—Whereas the man who travels at the rate of one degree to the east, will have all his days 4 minutes *shorter* than ours, so, on the contrary, the man who travels at the same rate towards the west, will have all his days 4 minutes *longer* than ours. When he has finished the circuit of the Earth, and arrived

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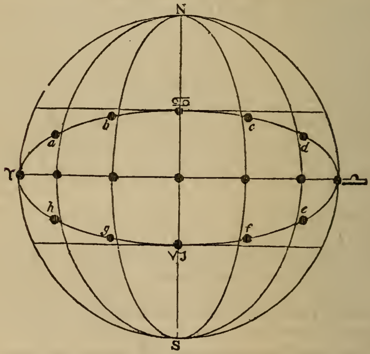
If the Earth revolved on its axis but once a year, and in the same direction as it revolves around the Sun, what would be the consequence as it regards day and night? *It was gravely reported some years ago by an American ship, that in sailing over the ocean, it found six Sundays in February; please explain this.*

at the place from which he first set out, he will have seen the Sun rise and set *once less* than we have. Consequently, the day he gets home will be *one day after* the time at that place: for which reason, if he arrives at home on Saturday, according to his own account, he will have to call the next day *Monday:* Sunday having gone by before he reached home. Thus, on whatever day of the week January should end, in common years, he would find the same day repeated only three times in February. If January ended on Sunday, he would, under these circumstances, find only *three Sundays in February.*

The Earth's motion about its axis being perfectly equable and uniform in every part of its annual revolution, the sidereal days are always of the same length, but the solar or natural days vary very considerably at different times of the year. This variation is owing to two distinct causes, the inclination of the Earth's axis to its orbit, and the inequality of its motion around the Sun. From these two causes it is, that the time shown by a well-regulated clock and that of a true sun-dial are scarcely ever the same. The difference between them, which sometimes amounts to 16¼ minutes, is called the *Equation of Time*, or the equation of solar days.

EQUATION OF TIME.

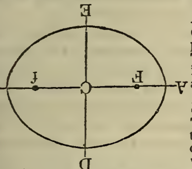


The difference between *mean* and *apparent* time, or, in other words, between *Equinoctial* and *Ecliptic* time, may be further shown by this figure, which represents the circles of the sphere. Let it be first premised, that *equinoctial* time is *clock* time; and that *ecliptic* time is *solar* or *apparent* time. It appears that from Aries to Cancer, the Sun in the ecliptic comes to the meridian *before* the equinoctial Sun: from Cancer to Libra, *after* it; from Libra to Capricorn, *before* it; and from Capricorn to Aries, *after* it. If we notice what months the

Why are the sidereal days always of the same length? What are the causes of the difference in the length of the solar days? What is meant by the expression, Equation of Time? *Illustrate the difference between mean and apparent time by reference to the above figure.*

Sun is in these several quarters, we shall find that from the 25th of December to the 16th of April, and from the 16th of June to the 1st of September, the *clock is faster* than the sun-dial: and that, from the 16th of April to the 16th of June, and from the 1st of September to the 25th of December, the *sun-dial* is faster than the clock.

It is a universal fact, that, while none of the planets are perfect spheres, none of their orbits are perfect circles. The planets all revolve about the Sun, in ellipses of different degrees of eccentricity; having the Sun, not in the center of the ellipse, but in one of its foci.



The figure A D B E is an *ellipse.* The line A B is called the transverse axis, and the line drawn through the middle of this line, and perpendicular to it, is the conjugate axis. The point C, the middle of the transverse axis, is the *center* of the ellipse. The points F and f, equally distant from C, are called the *foci.* C F, the distance from the center to one of the foci, is called the eccentricity. The orbits of the planets being ellipses, having the Sun in one of the foci, if A D B E be the orbit of a planet, with the Sun in the focus F, when the planet is at the point A, it will be in its *perihelion*, or nearest the Sun; and when at the point B in its *aphelion*, or at its greatest distance from the Sun. The difference in these distances is evidently equal to F f, that is, equal to twice the eccentricity of its orbit. In every revolution, a planet passes through its perihelion and aphelion. The eccentricity of the Earth's orbit is about one and a half millions of miles; hence she is three millions of miles nearer the Sun in her perihelion, than in her aphelion.

Now as the Sun remains fixed in the lower focus of the Earth's orbit, it is easy to perceive that a line, passing centrally through the Sun at right angles with the longer axis of the orbit, will divide it into two unequal segments. *Precisely thus it is divided by the equinoctial.*

That portion of the Earth's orbit which lies *above* the Sun, or *north* of the equinoctial, contains about 184 degrees; while that portion of it which lies *below* the Sun, or *south* of the equinoctial, contains only 176 degrees. This fact shows why the Sun continues about 8 days longer on the north side of the equator in summer, than it does on the south side in winter. The exact calculation, for the year 1830, is as follows:

	d.	h.	m.	d.	h.	m.
From the vernal equinox to the summer solstice,	= 92	21	19	186	11	19
From the summer solstice to the autumnal equinox,	= 93	14	1			
From the autumnal equinox to the winter solstice,	= 89	17	17	178	18	30
From the winter solstice to the vernal equinox,	= 89	1	13			
Difference in favor of the north side,				= 7	16	49

The points of the Earth's orbit which correspond to its greatest and least distances from the Sun, are called, the former the *Apogee*, and the latter the *Perigee;* two Greek words, the former of which signifies *from the Earth*, and the latter, *about the Earth.* These points are also designated by the common name of *Apsides.* [*See these points represented, Plate I.*]

What is the figure of the orbits of the planets? In what point of the orbits is the Sun situated? *What is the eccentricity of an orbit? How many times is a planet in its aphelion, and how many in its perihelion, in every revolution? How much farther is it from the Sun in the former case than in the latter? In which focus of the Earth's orbit is the Sun? How does the equinoctial divide the Earth's orbit?* Why does the Sun remain longer on the north side of the equator in summer, than it does on the south side in winter? *What are the Earth's Apogee and Perigee? By what common name are these two points designated?*

The Earth being in its perihelion about the 1st of January, and in its aphelion the 1st of July, we are three millions of miles nearer the Sun in winter than in midsummer. The reason why we have not, as might be expected, the hottest weather when the Earth is nearest the Sun, is, because the Sun, at that time, having retreated to the southern tropic, shines so obliquely on the northern hemisphere, that its rays have scarcely half the effect of the summer Sun; and continuing but a short time above the horizon, less heat is accumulated by day than is dissipated by night.

As the Earth performs its annual revolution around the Sun, the position of its axis remains invariably the same; always pointing to the North Pole of the heavens, and always maintaining the same inclination to its orbit. This seems to be providentially ordered for the benefit of mankind. If the axis of the Earth always pointed to the center of its orbit, all external objects would appear to whirl about our heads in an inexplicable maze. Nothing would appear permanent. The mariner could no longer direct his course by the stars, and every index in nature would mislead us.

THE MOON.

There is no object within the scope of astronomical observation which affords greater variety of interesting investigation than the various phases and motions of the Moon. From them the astronomer ascertains the form of the Earth, the vicissitudes of the tides, the causes of eclipses and occultations, the distance of the Sun, and, consequently, the magnitude of the solar system. These phenomena, which are perfectly obvious to the unassisted eye, served as a standard of measurement to all nations, until the advancement of science taught them the advantages of solar time. It is to these phenomena that the navigator is indebted for that precision of knowledge which guides him with well-grounded confidence through the pathless ocean.

The Hebrews, the Greeks, the Romans, and, in general, all the ancients, used to assemble at the time of new or full Moon, to discharge the duties of piety and gratitude for her

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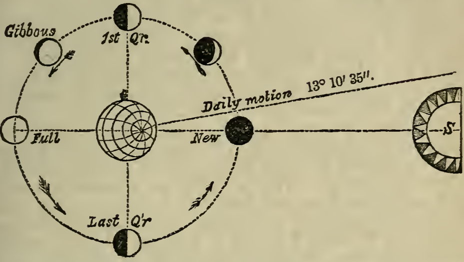
When is the Earth in its Perihelion? When in its Aphelion? Are we nearer the Sun in summer than in winter? How much nearer are we in winter than in summer? Why do we not have the hottest weather when we are nearest the Sun? As the Earth revolves about the Sun, what is the position of its axis? Should its axis always point to the center of its orbit, how would external objects appear to us? What important purposes does the Moon serve to the astronomer? Of what importance are her phenomena to the navigator? What nations used to assemble at the time of the new or of the full Moon, to express their gratitude for her benefits?

unwearied attendance on the Earth, and all her manifold uses.

The philosophy of the *changes* of the Moon is illustrated by the following cut:

PHILOSOPHY OF THE MOON'S CHANGES.



When the Moon, after having been in conjunction with the Sun, emerges from his rays, she first appears in the evening, a little after sunset, like a fine luminous crescent, with its convex side towards the Sun. If we observe her the next evening, we find her about 13° farther east of the Sun than on the preceding evening, and her crescent of light sensibly augmented. Repeating these observations, we perceive that she departs farther and farther from the Sun, as her enlightened surface comes more and more into view, until she arrives at her *first quarter*, and comes to the meridian at sunset. She has then finished half her course from the new to the full, and half her enlightened hemisphere is turned towards the Earth.

After her first quarter, she appears more and more *gibbous*, as she recedes farther and farther from the Sun, until she has completed just half her revolution around the Earth, and is seen rising in the east when the Sun is setting in the west. She then presents her enlightened orb *full* to our view, and is said to be in *opposition;* because she is then on the opposite side of the Earth with respect to the Sun.

In the first half of her orbit she appears to pass over our heads through the upper hemisphere; she now descends below the eastern horizon to pass through that part of her orbit which lies in the lower hemisphere.

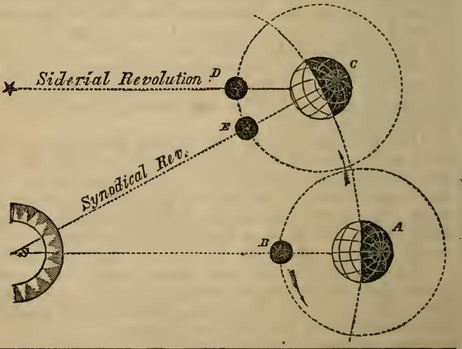
After her full she wanes through the same changes of ap-

Describe the apparent motion of the Moon, and her phases. How is it known that the Moon does not shine by her own light?

pearance as before, but in an inverted order; and we see her in the morning like a fine thread of light, a little west of the rising-sun. For the next two or three days she is lost to our view, rising and setting in *conjunction* with the Sun; after which, she passes over, by reason of her daily motion, to the *east* side of the Sun, and we behold her again a new Moon, as before. In changing sides with the Sun, she changes also the direction of her crescent. Before her conjunction it was turned to the east; it is now turned towards the west. These different appearances of the Moon are called her *phases*. They prove that she shines not by any light of her own; if she did, being globular, we should always see her a round full orb like the Sun.

The Moon is a satellite to the Earth, about which she revolves in an elliptical orbit, in 29 days, 12 hours, 44 minutes, and 3 seconds: the time which elapses between one new moon and another. This is called her *synodic* revolution. Her revolution from any fixed star to the same star again, is called her *periodic* or *sidereal* revolution. It is accomplished in 27 days, 7 hours, 43 minutes, and 11½ seconds; but in this time, the Earth has advanced nearly as many *degrees* in her orbit; consequently the Moon, at the end of one complete revolution, must go as many degrees farther, before she will come again into the same position with respect to the Sun and the Earth.

SIDEREAL AND SYNODIC REVOLUTIONS OF THE MOON.



About what does the Moon revolve, and what is the figure of her orbit? What is the time of her revolution from one new Moon to another? What is this revolution denominated? What is her periodic or sidereal revolution? In what time is this accomplished?

To illustrate: When the Earth is at A, and the Moon at B, the latter is in conjunction with the Sun. While the Earth moves on from A to C, the Moon makes a complete revolution around her, and reaches the point in her own orbit at D from which she started. But though she has now gone quite around the Earth, she is not now in conjunction with the Sun, as when at B, but must pass on from D to E, in order to come again in conjunction. It is obvious, therefore, that the *Synodical* exceeds the *Sidereal* revolution by the distance from D to E, which is just equal in degrees to the distance A C, in the Earth's orbit. This cut also shows why it takes 2 days and 5 hours longer for the Synodic than for the Sidereal revolution.

The *cause* of this difference is the same as that producing a disagreement between the Solar and Sidereal day, illustrated p. 206, namely, the advancement of the Earth in her orbit.

The Moon is the nearest of all the heavenly bodies, being about 30 times the diameter of the Earth, or 240,000 miles, distant from us. Her mean daily motion, in her orbit, is nearly 14 times as great as the Earth's; since she not only accompanies the Earth around the Sun every year, but, in the mean time, performs nearly 13 revolutions about the Earth.

Although the apparent motion of the Moon in her orbit, is greater than that of any other heavenly body, since she passes over, at a mean rate, no less than 13° 10′ 35″ in a day; yet this is to be understood as *angular motion*,—motion in a small orbit, and therefore embracing a great number of *degrees*, and but comparatively few miles.

As the Moon, while revolving about the Earth, is carried with it at the same time around the Sun, her path is extremely irregular, and very different from what it seems to be. Like a point in the wheel of a carriage, moving over a convex road, the Moon will describe a succession of epicycloidal curves, which are always concave towards the Sun; not very unlike their presentation in the following figure.*

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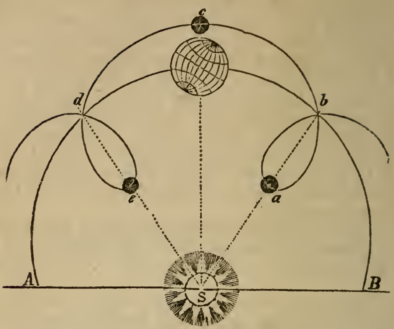
* This cut is perpetuated, not because the Moon ever actually retrogrades, and crosses her own path, but because the figure conveys a tolerable general idea of the Moon's motions, and helps to a more ready and accurate understanding of the true lunar orbit. The truth, as hereafter shown, is that the Moon never actually retrogrades, and always moves in a path concave towards the Sun.

To what is the difference of time in these two revolutions owing? How great is the distance of the Moon from the Earth, compared with that of the other heavenly bodies? What is her distance from us? What is her motion in her orbit, compared with the Earth's? How many times does she revolve around the Earth, every year? *The apparent motion of the Moon is greater in her orbit than that of any other heavenly body; is it to be understood that she passes through a correspondent space?* Describe the Moon's path.

THE MOON'S MOTION.



Let *A d b B* represent a portion of the Earth's orbit; and *a b c d e* the lunar orbit. When the Earth is at *b*, the new Moon is at *a;* and while the Earth is moving from *b* to its position as represented in the figure, the Moon has moved through half her orbit, from *a* to *c*, where she is full; so while the Earth is moving from its present position to *d*, the Moon describes the other half of her orbit from *c* to *e;* where she is again in conjunction.

The preceding, however, is by no means an *accurate* representation of the Moon's orbit, though it affords a good general idea of her path and revolutions. A better "Theory," as it is termed, will be found illustrated in Plate 1 of the Atlas, but this also fails to exhibit the real orbit of the Moon. This is far more accurately shown in the following cut, in which the dark curve line represents the Earth's path, and the variable dotted line the orbit of the Moon. The cord A B extending from one crossing to another passes more than 400,000 miles from the Earth; but as the Moon only departs 240,000 miles from us, it follows that her path must be *concave towards the Sun*, as shown in the figure, even while within the Earth's orbit. She must be more than 400,000 miles from the Earth to describe an orbit in the least *convex* towards the Sun, at any time.

The Moon, though apparently as large as the Sun, is the smallest of all the heavenly bodies that are visible to the naked eye. Her diameter is but 2162 miles; consequently her surface is 13 times less than that of the Earth, and her bulk 49 times less. It would require 70 millions of such

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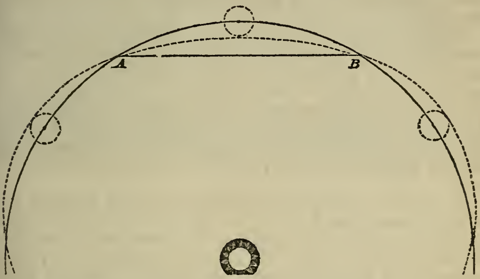
What is her magnitude, compared with that of the other heavenly bodies? What is her diameter? How great are her surface and her bulk, compared with those of the Earth? How many such bodies would it require to equal the volume of the Sun? Why does she appear as large as the Sun, when in reality she is so much less?

bodies to equal the volume of the Sun. The reason why she appears as large as the Sun, when, in truth, she is so much less, is because she is 400 times nearer to us than the Sun.

TRUE ORBIT OF THE MOON.



The Moon revolves once on her axis exactly in the time that she performs her revolution around the Earth. This is evident from her always presenting the same side to the Earth; for if she had no rotation upon an axis, every part of her surface would be presented to a spectator on the Earth, in the course of her synodical revolution. It follows, then, that there is but *one day and night in her year*, containing, both together, 29 days, 12 hours, 44 minutes, and 3 seconds.

As the Moon turns on her axis only as she moves around the Earth, it is plain that the inhabitants of one half of the lunar world are totally deprived of the sight of the Earth, unless they travel to the opposite hemisphere. This we may presume they will do, were it only to view so sublime a spectacle; for it is certain that from the Moon the Earth appears *ten times larger* than any other body in the universe.

As the Moon enlightens the Earth, by reflecting the light of the Sun, so likewise the Earth illuminates the Moon, exhibiting to her the same phases that she does to us, only in a contrary order. And, as the surface of the Earth is 13 times as large as the surface of the Moon, the Earth, when full to the Moon, will appear 13 times as large as the full Moon does to us. That side of the Moon, therefore, which

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What is the time of her revolution on her axis, compared with that of her revolution around the Earth? How is this proved? How many days and nights then has she in the course of her synodical revolution? What is the length of both united? Describe the phenomena of the Earth as seen by the inhabitants of the Moon is towards the Earth, may be said to have no darkness at all, the Earth constantly shining upon it with extraordinary splendor when the Sun is absent; it therefore enjoys successively two weeks of illumination from the Sun, and two weeks of earth-light from the Earth. The other side of the Moon has alternately a fortnight's light, and a fortnight's darkness.

As the arth revolves on its axis, the several continents, seas, and islands, appear to the lunar inhabitants like so many spots, of different forms and brightness, alternately moving over its surface, being more or less brilliant, as they are seen through intervening clouds. By these spots, the lunarians can not only determine the period of the Earth's rotation, just as we do that of the Sun, but they may also find the longitude of their places, as we find the latitude of ours.

As the full Moon always happens when the Moon is directly opposite the Sun, all the full Moons in our *winter*, must happen when the Moon is on the *north* side of the equinoctial, because *then* the Sun is on the *south* side of it; consequently, at the north pole of the Earth, there will be a fortnight's moon-light and a fortnight's darkness by turns, for a period of six months, and the same will be the fact during the Sun's absence the other six months, at the south pole.

The Moon's axis being inclined only about 1½° to her orbit, she can have no sensible diversity of seasons; from which we may infer, that her atmosphere is mild and uniform. The quantity of light which we derive from the Moon when full, is at least 300 thousand times less than that of the Sun.*

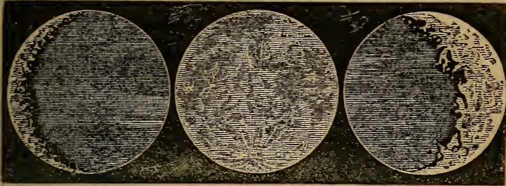
When viewed through a good telescope, the Moon presents a most wonderful and interesting aspect. Besides the large dark spots, which are visible to the naked eye, we perceive extensive valleys, shelving rocks, and long ridges of elevated mountains, projecting their shadows on the plains below. Single mountains occasionally rise to a great height,

* This is Mons. Bouquer's inference, from his experiments, as stated by La Place, in his work, p. 42. The result of Dr. Wollaston's computations was different. Professor Leslie makes the light of the Moon 150,000 times less than that of the Sun: it was formerly reckoned 100,000 times less.

As the Earth revolves on its axis, how do its continents, seas, and islands, appear to the lunar inhabitants? For what purposes may these spots serve to the lunarians? What are the periods of the Moon's presence and absence to the polar inhabitants? Explain this. Why cannot the Moon have any sensible diversity of seasons? What then may we infer to be the character of her atmosphere? What is the quantity of light which she affords when full, compared with that of the Sun? Describe the appearance of the Moon when seen through a good telescope. What mountains of the Earth does her mountain scenery resemble?

while circular hollows, more than *three miles* deep, seem excavated in the plains.

TELESCOPIC VIEWS OF THE MOON.



Her mountain scenery bears a striking resemblance to the towering sublimity and terrific ruggedness of the Alpine regions, or of the Apennines, after which some of her mountains have been named, of and the Cordilleras of our own continent. Huge masses of rock rising precipitously from the plains, lift their peaked summits to an immense height in the air, while shapeless crags hang over their projecting sides, and seem on the eve of being precipitated into the tremendous chasm below.

Around the base of these frightful eminences, are strewed numerous loose and unconnected fragments, which time seems to have detached from their parent mass; and when we examine the rents and ravines which accompany the overhanging cliffs, the beholder expects every moment that they are to be torn from their base, and that the process of destructive separation which he had only contemplated in its effects, is about to be exhibited before him in all its reality.

The range of mountains called the Apennines, which traverses a portion of the Moon's disc from north-east to south-west, and of which some parts are visible to the naked eye, rise with a precipitous and craggy front from the level of the *Mare Imbrium*, or Sea of Showers.* In this extensive range are several ridges whose summits have a perpendicular elevation of four miles, and more; and though they often descend to a much lower level, they present an inaccessible barrier on the north-east, while on the south-west they sink in gentle declivity to the plains.

* The name of a lunar spot.

Describe the appearance of her mountains. On what part of her disc is that range of mountains called the Apennines, situated? Describe it. What remarkable feature in the Moon's surface, bears no analogy to any thing observable on the Earth's surface?

There is one remarkable feature in the Moon's surface which bears no analogy to any thing observable on the Earth. This is the circular cavities which appear in every part of her disc. Some of these immense caverns are nearly four miles deep, and forty miles in diameter. They are most numerous in the south-western part. As they reflect the Sun's rays more copiously, they render this part of her surface more brilliant than any other. They present to us nearly the same appearance as our Earth might be supposed to present to the Moon, if all our great lakes and seas were dried up.

The number of remarkable spots on the Moon, whose latitude and longitude have been accurately determined, exceeds 200. The number of seas and lakes, as they were formerly considered, whose length and breadth are known, is between 20 and 30; while the number of peaks and mountains, whose perpendicular elevation varies from a fourth of a mile to five miles in height, and whose bases are from one to seventy miles in length, is not less than one hundred and fifty.*

Graphical views of these natural appearances, accompanied with minute and familiar descriptions, constitute what is called *Selenography*, from two Greek words, which mean the same thing in regard to the Moon, as *Geography* does in regard to the Earth.

An idea of some of these scenes may be formed by conceiving a plane of about 100 miles in circumference, encircled by a range of mountains, of various forms, three miles in perpendicular height, and having a mountain near the center, whose top reaches a mile and a half above the level of the plain. From the top of this central mountain, the whole plain, with all its scenery, would be distinctly visible, and the view would be bounded only by a lofty amphitheatre of mountains, rearing their summits to the sky.

The bright spots of the Moon are the mountainous regions; while the dark spots are the plains, or more level parts of her surface. There may be rivers or small lakes

* Brewster's *Selenography.* The best maps of the Moon hitherto published, are those by Schroeter; but the most curious and complete representation of the telescopic and natural appearances of the Moon, is to be seen in Russel's *Lunar Globe,* See also *Selenographia,* by C. Blunt.

Describe their appearance. What is the number of remarkable spots on the Moon's surface, whose latitude and longitude have been accurately determined? What is the number of seas and lakes, as they were formerly considered, whose dimensions are known? What is the number of peaks and mountains whose perpendicular elevation varies from a fourth of a mile to five miles, and whose bases are from one to seventy miles in length? *What is Selenography?* Give an illustration to enable us to form some idea of some of these scenes. Which spots are the mountainous regions, and which the plains? Do astronomers now suppose, as they did formerly, that there are large collections of water on the Moon's surface? Are any of her mountains and valleys visible to the naked eye? How small a spot on the Moon's surface can be seen by a telescope which magnifies 100 times?

on this planet; but it is generally thought, by astronomers of the present day, that there are no seas or large collections of water, as was formerly supposed. Some of these mountains and deep valleys are visible to the naked eye; and many more are visible through a telescope of but moderate powers.

A telescope which magnifies only 100 times, will show a spot on the Moon's surface, whose diameter is 1223 yards; and one which magnifies a thousand times, will enable us to perceive any enlightened object on her surface whose dimensions are only 122 yards, which does not much exceed the dimensions of some of our public edifices, as for instance, the Capitol at Washington, or St. Paul's Cathedral. Professor Frauenhofer, of Munich, recently announced that he had discovered a lunar edifice, resembling a *fortification*, together with *several lines of road*. The celebrated astronomer Schroeter, conjectures the existence of a great city on the east side of the Moon, a little north of her equator, an extensive canal in another place, and fields of vegetation in another.

SOLAR AND LUNAR ECLIPSES.

Of all the phenomena of the heavens, there are none which engage the attention of mankind more than eclipses of the Sun and Moon; and to those who are unacquainted with astronomy, nothing appears more wonderful than the accuracy with which they can be predicted. In the early ages of antiquity they were regarded as alarming deviations from the established laws of nature, presaging great public calamities, and other tokens of the divine displeasure.

In China, the prediction and observance of eclipses are made a matter of state policy, in order to operate upon the fears of the ignorant, and impose on them a superstitious regard for the occult wisdom of their rulers. In Mexico, the natives fast and afflict themselves, during eclipses, under an apprehension that the Great Spirit is in deep sufferance. Some of the northern tribes of Indians have imagined that the Moon had been wounded in a quarrel; and others, that she was about to be swallowed by a huge fish.

It was by availing himself of these superstitious notions, that Columbus, when shipwrecked on the island of Jamaica, extricated himself and crew from a most embarrassing condition. Being driven to great distress for want of provisions, and the natives refusing him any assistance, when all hope seemed to

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How small an enlightened object can be seen by one which magnifies 1000 times? Mention any public edifices which are of nearly the same dimensions. How were eclipses regarded in the early ages of antiquity? *To what purpose do the rulers of China make their prediction and observance subservient? How do the natives of Mexico demean themselves during an eclipse? Why do they do this? What notions have some of the northern tribes of Indians entertained with regard to eclipses of the Moon? Relate the anecdote of Columbus extricating himself and his crew from distress, by availing himself of the superstitious notions of the natives of Jamaica in regard to eclipses.*

be cut off, he bethought himself of their superstition in regard to eclipses. Having assembled the principal men of the island, he remonstrated against their inhumanity, as being offensive to the Great Spirit: and told them that a great plague was even then ready to fall upon them, and as a token of it, they would that night see the Moon hide her face in anger, and put on a dreadfully dark and threatening aspect. This artifice had the desired effect; for the eclipse had no sooner begun, than the frightened barbarians came running with all kinds of provisions, and throwing themselves at the feet of Columbus, implored his forgiveness.—*Almagest, Vol. I.* 55 *c. v.* 2.

An eclipse of the Sun takes place, when the dark body of the Moon, passing directly between the Earth and the Sun, intercepts his light. This can happen only at the instant of *new* Moon, or when the Moon is in conjunction; for it is only then that she passes between us and the Sun.

An eclipse of the Moon takes place when the dark body of the Earth, coming between her and the Sun, intercepts his light, and throws a shadow on the Moon. This can happen only at the time of *full* Moon, or when the Moon is in opposition; for it is only then that the Earth is between her and the Sun.

As every planet belonging to the solar system, both primary and secondary, derives its light from the Sun, it must cast a shadow towards that part of the heavens which is opposite to the Sun. This shadow is of course nothing but a privation of light in the space hid from the Sun by the opaque body, and will always be proportioned to the magnitude of the Sun and planet.

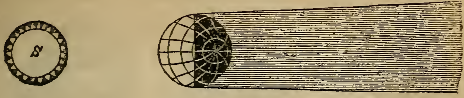
If the Sun and planet were both of the same magnitude, the form of the shadow cast by the planet, would be that of a cylinder, and of the same diameter as the Sun or planet.

CYLINDRICAL SHADOW.

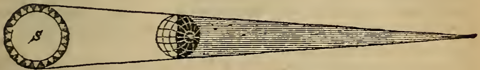
If the planet were *larger* than the Sun, the shadow would continually diverge, and grow larger and larger; but as the Sun is much larger than any of the planets, the shadows which they cast must converge to a point in the form of a cone, the length of which will be proportional to the size and distance of the planet from the Sun.

What causes eclipses of the Sun? What causes eclipses of the Moon? In what direction does every planet of the solar system cast a shadow? What is this shadow, and to what is it proportional? If the Sun and planet were both of the same magnitude, what would be the form of the shadow, and its diameter? If the planet were *larger* than the Sun, what would be the form of the shadow? But as the Sun is much larger than any of the planets, what must be the form of their shadows, and to what are they proportional?

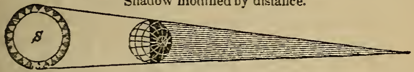
DIVERGING SHADOW.



CONVERGING SHADOWS.



Shadow modified by distance.



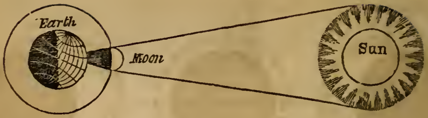
The magnitude of the Sun is such, that the shadow cast by each of the primary planets always converges to a point before it reaches any other planet; so that not one of the primary planets can eclipse another. The shadow of any planet which is accompanied by Satellites, may, on certain occasions, eclipse its satellites; but it is not long enough to eclipse any other body. The shadow of a satellite or Moon, may also, on certain occasions, fall on the primary, and eclipse it.

When the Sun is at his *greatest* distance from the Earth, and the Moon at her *least* distance, her shadow is sufficiently long to reach the Earth, and extend 19,000 miles beyond. When the Sun is at his *least* distance from the Earth, and the Moon at her *greatest*, her shadow will not reach the Earth's surface by 20,000 miles. So that when the Sun and Moon are at their *mean* distances, the cone of the Moon's shadow will terminate a little before it reaches the Earth's surface.

In the former case, if a conjunction take place when the center of the Moon comes in a direct line between the centers of the Sun and Earth, the dark shadow of the Moon will fall centrally upon the Earth, and cover a circular area of 175 miles in diameter. To all places lying within this dark spot, the Sun will be totally eclipsed, as illustrated by the figure.

Why can no one of the primary planets eclipse another? Explain how, on certain occasions, they may eclipse their satellites, and on others be eclipsed by them. When the Sun is at his *greatest* distance from the Earth, and the Moon at her *least* distance, how far will her shadow extend? When the Sun is at his *least* distance, and the Moon at her *greatest*? When the Sun and Moon are both at their *mean* distances? In the first case, *in what circumstances* will the Moon's shadow fall centrally on the Earth, and what will be its figure and diameter? How will the Sun appear to all places lying within this dark spot? *Describe the effect of the Earth's motion, during the eclipse, upon this circular area.*

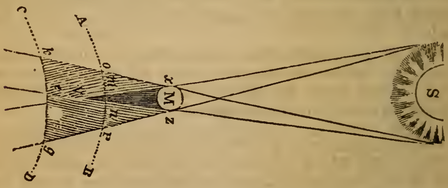
ECLIPSES OF THE SUN.



In consequence of the Earth's motion during the eclipse, this circular area becomes a continued belt over the Earth's surface; being, at the broadest, 175 miles wide. This belt is, however, rarely so broad, and often dwindles to a mere nominal line, without total darkness.

In March, this line extends itself from S. W. to N. E., and in September, from N. W. to S. E. In June, the central line is a curve, going first to the N. E., and then to the S. E.; in December, on the contrary, first to the S. E., and then to the N. E. To all places within 2000 miles at least of the central line, the eclipse will be visible; and the nearer the place of observation is to the line, the larger will be the eclipse. In winter, if the central trace be but a little northward of the equator, and in summer, if it be 25 degrees N. latitude, the eclipse will be visible all over the northern hemisphere. As a general rule, though liable to many modifications, we may observe, that places from 200 to 250 miles from the central line, will be 11 digits eclipsed; from thence to 500 miles, 10 digits; and so on, diminishing one digit in about 250 miles.

If, in either of the other cases, a conjunction take place when the Moon's center is directly between the centers of the Sun and Earth, as before, the Moon will then be too distant to cover the entire face of the Sun, and there will be seen, all around her dark body, a slender ring of dazzling light.



This may be illustrated by the above figure. Suppose C D to represent a part of the Earth's orbit, and the Moon's shadow to terminate at the vertex V.; the small space between *e f* will represent the breadth of the luminous ring which will be visible all around the dark body of the Moon.

The appearance and progress of an *annular* eclipse, is illustrated by the following cut, where the dark body of

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In either of the other cases, the same circumstances occurring as before, what will be the appearance of the Sun? Why does not the Moon, in this case, cause a total eclipse? *When did the first eclipse of this kind, ever visible in the United States, happen? How long did the luminous ring, along its path, remain unbroken? When did the next annular eclipse, visible to any considerable portion of the United States, happen?*

the Moon is seen resting upon the center of the Sun, and leaving a luminous ring unobscured.

ECLIPSE OF THE SUN.

Such was the eclipse of February, 12, 1831, which passed over the southern states, from S. W. to N. E. It was the first annular eclipse ever visible in the United States. Along the path of this eclipse, the luminous ring remained perfect and unbroken for the space of two minutes. The last annular eclipse visible to any considerable portion of the United States, took place Sept. 18th, 1838.

From the most elaborate calculations, compared with a long series of observations, the length of the Moon's shadow in eclipses, and her distance from the Sun at the same time, vary within the limits of the following table:

Length of Shadow, Dist. of Moon.	Length of Shadow in Semidiameters.	Length in miles.	Distance in Semidiameters.	Distance in miles.
Least	57.760×3956=	228,499	55.902×3956=	221,148
Mean	58.728×3956=	232,328	60.238×3956=	238,300
Greatest	59.730×3956=	236,292	63.862×3956=	252.638

Thus it appears that the length of the cone of the Moon's shadow, in eclipses, varies from 228,499 to 236,292 miles; being 7,793 miles longer in the one case, than in the other. The inequality of her distances from the Earth is much greater; they vary from 221,148 to 252,638 miles, making a difference of 31,490 miles.

Although a central eclipse of the Sun can never be total to any spot on the Earth more than 175 miles broad; yet the space over which the Sun will be more or less *partially* eclipsed, is nearly 5000 miles broad.

The section of the Moon's shadow, or her penumbra, at the Earth's surface, in eclipses, is far from being always circular. If the conjunction happen when the center of the Moon is a little *above* or a little *below* the center of the line joining the centers of the Earth and Sun, as is most frequently the case, the shadow will be projected *obliquely* over the Earth's surface, and thus cover a much larger space.

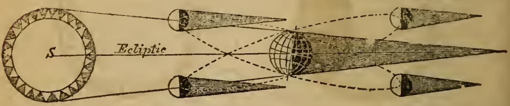
To produce a partial eclipse, it is not necessary that the shadow should reach the Earth; it is sufficient that the apparent distance between the Sun and Moon be not greater than the sum of their semidiameters.

What are the limits between which the Moon's shadow varies in eclipses? What is the difference between these two limits? What are the limits of her distances from the Earth? What is the difference between them? What is the greatest breadth of any spot on the Earth's surface, to which a central eclipse of the Sun can be total? What is the breadth of the greatest space over which the Sun can be more or less partially eclipsed? *Is the penumbra of the Moon at the Earth's surface in eclipses always circular? In what circumstances will the shadow be projected obliquely over the Earth's surface? Must the shadow reach the Earth, to produce a partial eclipse? What is the greatest apparent distance between the Sun and Moon, within which such a result will take place?* Why is not the Sun eclipsed at the time of every new Moon, and the Moon at every full? In what circumstances will an eclipse of the Sun, and in what an eclipse of the Moon, happen?

If the Moon performed her revolution in the same path in which the Sun appears to move; in other words, if her orbit lay exactly in the plane of the Earth's orbit, the Sun would be eclipsed at the time of every new Moon, and the Moon at the time of every full. But one half of the Moon's orbit lies about 5° on the north side of the ecliptic, and the other half as far on the south side of it; and, consequently, the Moon's orbit only crosses the Earth's orbit in two opposite points, called the Moon's nodes. [For an explanation of the Nodes of a planet's orbit, see page 186 and cut.]

When the Moon is in one of these points, or nearly so, at the time of *new* Moon, the Sun will be eclipsed. When she is in one of them, or nearly so, at the time of *full* Moon, the Moon will be eclipsed. But at all other new Moons, the Moon either passes above or below the Sun, as seen from the Earth; and, at all other full Moons, she either passes above or below the Earth's shadow; and consequently there can be no eclipse.

NEW AND FULL MOONS WITHOUT ECLIPSES.



In the preceding cut, one of the nodes is between the eye of the observer and the Earth, and the other beyond the Earth. Of course then the Moon would pass either above or below the Earth's shadow at full Moon, and either above or below the Sun at new Moon, so that no eclipse would be produced in either case.

If the Moon be *exactly* in one of her nodes at the time of her change, the Sun will be centrally eclipsed. If she be 1½° from her node at the time of her change, the Sun will appear at the equator to be about 11 digits eclipsed. If she be 3° from her node at the time of her change, the Sun will be 10 digits eclipsed, and so on; a digit being the twelfth part of the Sun's diameter. But when the Moon is about 18° from her node, she will just touch the outer edge of the Sun, at the time of her change, without producing any eclipse. These are called the *ecliptic limits.* Between

In what circumstances is the Sun centrally eclipsed? What is the ratio between the Moon's distance from her node, and the number of digits that the Sun is eclipsed? What are these limits called? Will there always be eclipses when the Moon is within these limits? *What is the ecliptic limit for the Sun? What is it for the Moon? What number of degrees, then, are there about each node, and how many out of 360°, in which solar eclipses can happen? How many in which lunar eclipses usually happen?*

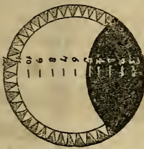
these limits, an eclipse is doubtful, and requires a more exact calculation.

The mean ecliptic limit for the Sun is 16½° on each side of the node, the mean ecliptic limit for the Moon is 10½° on each side of the node. In the former case, then, there are 33 degrees about each node, making, in all, 66° out of 360°, in which eclipses of the Sun may happen: in the latter case, there are 21° about each node, making, in all, 42° out of 360° in which eclipses of the Moon usually occur. The proportion of the solar to the lunar eclipses, therefore, is as 66 to 42, or as 11 to 7. Yet, there are more visible eclipses of the Moon at any given place than of the Sun; because a lunar eclipse is visible to a whole hemisphere, a solar eclipse only to a small portion of it.

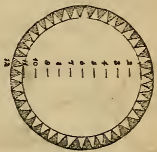
The greatest possible duration of the annular appearance of a solar eclipse, is 12 minutes and 24 seconds; and the greatest possible time during which the Sun can be totally eclipsed, to any part of the world, is 7 minutes and 58 seconds. The Moon may continue totally eclipsed for one hour and three quarters.

The diameter of the Sun and Moon, respectively, is divided into twelve equal parts, called *Digits*, thus:

Five Digits eclipsed.



Twelve Digits.



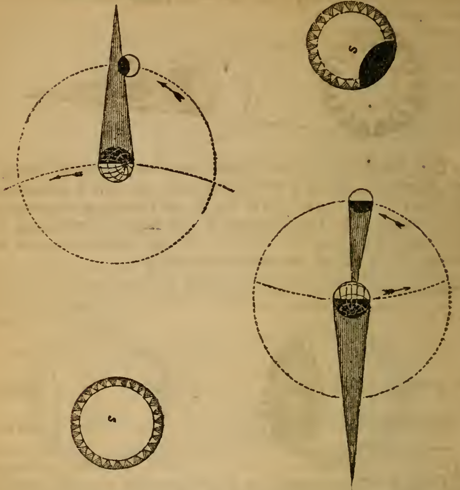
Here it will be observed, that a digit is not a twelfth part of the *surface* of the Sun or Moon, but the twelfth part of their respective *diameters*. Consequently, when the concave limb of the Moon covers five digits of the Sun, as shown in the left hand figure, it will obscure considerably less than five twelfths of the Sun's *surface*.

Eclipses of the Sun always begin on his western edge, and end on his eastern; but all eclipses of the Moon commence on her eastern edge, and end on her western.

The reason for this will be well understood by the aid of the accompanying figures.

What then is the proportion of the solar to the lunar eclipses? Why then are there more eclipses of the Moon visible at any given place than of the Sun? What is the greatest possible duration of the annular appearance of a solar eclipse? What is the greatest possible duration of a total solar eclipse to any part of the world? What is the greatest duration of a total lunar eclipse? On which side of the Sun do solar eclipses always begin, and on which do they end? On which side of the Moon do lunar eclipses always begin, and on which do they end? In what circumstances is the Moon totally eclipsed? Beyond what distance from her node, if she be, will she only touch the Earth's shadow, and not be eclipsed? *On what then does the duration of lunar eclipses depend?* What is meant by *Digits*, in the description of eclipses? Suppose six digits are eclipsed, do they amount to half the Sun's surface? If not, why?

Lunar Eclipse. Solar Eclipse.



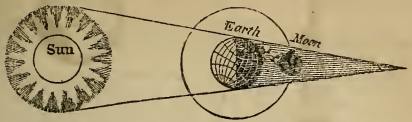
Let the student turn his face to the south, and hold the book up open before him, and he will see at once, by the right hand figure, that the Moon, in going eastward, must obscure the *west* or *right hand side* of the Sun first. In the figure on the left, the Moon, in revolving eastward as before, comes in contact with the *west side* of the Earth's *shadow* first, consequently her own *eastern* limit is first obscured.

If the Moon, at the time of her opposition, be exactly in her node, she will pass through the center of the Earth's shadow, and be totally eclipsed. If, at the time of her opposition, she be within 6° of her node, she will still pass through the Earth's shadow, though not centrally, and be totally eclipsed: but if she be 12° from her node, she will only just touch the Earth's shadow, and pass it without being eclipsed.

The duration of lunar eclipses, therefore, depends upon the difference between the diameter of the Moon and that section of the Earth's shadow through which she passes. When an eclipse of the Moon is both total and central, its duration is the longest possible, amounting nearly to 4 hours; but the duration of all eclipses *not* central varies with her distance from the node.

In what circumstances is the duration of the lunar eclipse the longest possible? What is the length of the greatest duration of a lunar eclipse? With what does the duration of eclipses, not central, vary?

ECLIPSES OF THE MOON.



The *diameter* of the Earth's shadow, at the distance of the Moon, is nearly three times as large as the diameter of the Moon; and the *length* of the Earth's shadow is nearly four times as great as the distance of the Moon; exceeding it in the same ratio that the diameter of the Earth does the diameter of the Moon, which is as 3.663 to 1.

The length of the Earth's shadow, and its diameter at the distance of the Moon, are subject to the variations exhibited in the following table:		Diameter of the shadow.	Length of the shadow in miles.
Sun at the perigee	Moon at the apogee	5,232	842,217
	Moon at her mean distance	5,762	
	Moon at the perigee	6,292	
Sun at his mean distance	Moon at the apogee	5,270	856,597
	Moon at her mean distance	5.799	
	Moon at the perigee	6,329	
Sun at the apogee	Moon at the apogee	5,306	871,262
	Moon at her mean distance	5.836	
	Moon at the perigee	6,365	

The first column of figures expresses the diameter of the Earth's shadow at the Moon: and as the diameter of the Moon is only 2162 miles, it is evident that it can always be comprehended by the shadow, which is more than twice as broad as the disc of the Moon.

The time which elapses between two successive changes of the Moon is called a *Lunation*, which, at a mean rate, is about 29½ days. If 12 lunar months were exactly equal to the 12 solar months, the Moon's nodes would always occupy the same points in the ecliptic, and all eclipses would happen in the same months of the year, as is the case with the transits of Mercury and Venus: but, in 12 lunations, or lunar months, there are only 354 days; and in this time the Moon has passed through both her nodes, but has not quite accomplished her revolution around the Sun: the consequence is, that the Moon's nodes fall back in the ecliptic at the rate of about 19⅓° annually; so that the eclipses happen sooner every year by about 19 days.

What is the diameter of the Earth's shadow at the distance of the Moon? What is the length of the Earth's shadow? What is their ratio to each other? *Between what limits does the length of the Earth's shadow, and its diameter at the distance of the Moon, vary? What is the breadth of the Earth's shadow compared with that of the disc of the Moon?* What is a lunation? How many days does a lunation embrace? Why do not all eclipses happen in the same months of the year? How far do the Moon's nodes fall back in the ecliptic annually, and how much so[illegible] the eclipses happen every year?

As the Moon passes from one of her nodes to the other in 173 days, there is just this period between two successive eclipses of the Sun, or of the Moon. In whatever time of the year, then, we have eclipses at either node, we may be sure that in 173 days afterwards, we shall have eclipses at the other node.

As the Moon's nodes fall back, or retrograde in the ecliptic, at the rate of 19⅓° every year, they will complete a backward revolution entirely around the ecliptic to the same point again, in 18 years, 225 days; in which time there would always be a regular period of eclipses, if any complete number of lunations were finished without a remainder. But this never happens; for if both the Sun and Moon should start from a line of conjunction with either of the nodes in any point of the ecliptic, the Sun would perform 18 annual revolutions and 222° of another, while the Moon would perform 230 lunations, and 85° of another, before the node would come around to the same point of the ecliptic again; so that the Sun would then be 138° from the node, and the Moon 85° from the Sun.

But after 223 lunations, or 18 years, 11 days,* 7 hours, 42 minutes, and 31 seconds, the Sun, Moon, and Earth, will return so nearly in the same position with respect to each other, that there will be a *regular return of the same eclipses for many ages.* This grand period was discovered by the Chaldeans, and by them called *Saros.* If therefore, to the mean time of any eclipse, either of the Sun or Moon, we add the Chaldean period of 18 years and 11 days, we shall have the return of the same eclipse. This mode of predicting eclipses will hold good for a thousand years. In this period there are usually 70 eclipses; 41 of the Sun and 29 of the Moon.

The number of eclipses in any one year, cannot be less than two, nor more than seven. In the former case, they will both be of the Sun; and in the latter, there will be five of the Sun, and two of the Moon—those of the Moon will be total. There are sometimes six; but the usual number is four: two of the Sun, and two of the Moon.

The cause of this variety is thus accounted for. Although the Sun usually passes by both nodes only once in a year, he may pass the same node again a little before the end of the year. In consequence of the retrograde motion of the Moon's nodes, he will come to either of them 173 days after passing the other. He may, therefore, return to the same node in about 346 days, having thus passed one node *twice* and the other *once*, making each time, at each, an eclipse of both the Sun and the Moon, or, *six* in all. And since 12 lunations, or 354 days from the *first* eclipse, in the *beginning* of the year, leave room for another new Moon before the close of the year, and since this new Moon may fall within the ecliptic limit, it is possible for the Sun to be eclipsed again. Thus there may be *seven* eclipses in the same year.

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* If there are *four* leap years in this interval, add 11 days; but if there are *five*, add only ten days.

In what time does the Moon pass from one of her nodes to the other? What is the length of the time which elapses between two successive eclipses of the Sun or the Moon? After there have been eclipses at one node, in what time may we be sure that there will be eclipses at the other? *In what time do the Moon's nodes complete a backward revolution around the ecliptic? Why is there not always a regular period of eclipses in this time? If the Sun and Moon should both start from a line of conjunction with either node, how many revolutions would the Sun perform, and how many lunations the Moon, before the node would come around to the same point again? After how many lunations will the Sun, Moon, and Earth, return so nearly to the same position with respect to each other, that there will be a regular return of the same eclipses for many ages? What nation discovered this grand period, and what did they call it? What is the mode of predicting eclipses, with which this fact furnishes us? How many eclipses are there usually in this period?* What is the least, and what the greatest number of eclipses, in any one year? In the former case, what eclipses will they be? What, in the latter? What is the usual number of eclipses in the year, and what eclipses are they? *Please explain the cause of this variety.*

Again: when the Moon changes in either of her nodes, she cannot come within the lunar ecliptic limit at the next full, (though if she be *full* in one of her nodes, she may come into the *solar* ecliptic limit at her next *change*,) and six months afterwards, she will change near the other node; thus making only two eclipses.

The following is a list of all the solar eclipses that will be visible in Europe and America during the remainder of the present century. To those which will be visible in New England, the number of digits is annexed

Year.	Month	Day and hour.	Digits	Year.	Month.	Day and hour.	Digits.
1851,	July	28 7 48 A. M.	3⅔	1876,	Mar.	25 4 11 P. M.	3⅗
1854,	May	26 4 26 P. M.	11½	1878,	July	29 4 56 P. M.	7½
1858,	Mar.	15 6 14 A. M.	1⅔	1879,	July	19 2 0 A. M.	
1859,	July	29 5 32 P. M.	2½	1880,	Dec.	31 7 30 A. M.	5½
1860,	July	18 7 23 A. M.	6⅓	1882,	May	17 1 0 A. M.	
1861,	Dec.	31 7 30 A. M.	4½	1885,	Mar.	16 0 35 A. M.	6½
1863,	May	17 1 0 P. M.		1886,	Aug.	29 6 30 A. M.	0¼
1865,	Oct.	19 9 10 A. M.	3⅗	1887,	Aug.	18 10 0 P. M.	
1866,	Oct.	8 11 12 A. M.	0	1890,	June	17 3 0 A. M.	
1867,	Mar.	6 3 0 A. M.		1891,	June	6 0 0 Mer.	
1868,	Feb.	23 10 0 A. M.		1892,	Oct.	20 0 19 P. M.	8¼
1869,	Aug.	7 5 21 A. M.	10¼	1895,	Mar.	26 4 0 A. M.	
1870,	Dec.	22 6 0 A. M.		1896,	Aug.	9 0 0 Mer.	
1873,	May	26 3 0 A. M.		1897,	July	29 9 8 A. M.	4½
1874,	Oct.	10 4 0 A. M.		1899,	June	8 0 0 Mer.	
1875,	Sept.	29 5 56 A. M.	11½	1900,	May	28 8 9 A. M.	11

The eclipses of 1854, 1869, 1875, and 1900, will be very large. In those of 1858, 1861, 1873, 1875. and 1880, the *Sun will rise eclipsed*.

Those of 1854 and 1875, will be *annular*. The scholar can continue this table, or extend it backwards, by adding or subtracting the Chaldean period of 18 years, 11 days, 7 hours, 54 minutes, and 31 seconds.

MARS.

Mars is the first of the exterior planets, its orbit lying immediately without, or *beyond*, that of the Earth, while those of Mercury and Venus are *within*.

Mars appears, to the naked eye, of a fine ruddy complexion; resembling, in color, and apparent magnitude, the star Antares, or Aldebaran, near which it frequently passes. It exhibits its greatest brilliancy about the time that it rises when the Sun sets, and sets when the Sun rises; because it is then nearest the Earth. It is least brilliant when it rises and sets with the Sun; for then it is five times farther removed from us than in the former case.

Its distance from the Earth at its nearest approach is about 50 millions of miles. Its greatest distance from us is about 240 millions of miles. In the former case, it appears nearly

What is the position of Mars in the solar system? Describe its appearance to the naked eye. When does it exhibit its greatest brilliancy? Why is it most brilliant at this time? What are its least and greatest distances from us? How much larger does it appear in the former case than in the latter?

25 times larger than in the latter. When it rises before the Sun, it is our morning star; when it sets after the Sun, it is our evening star.

The distance of all the planets from the Earth, whether they be interior or exterior planets, varies within the limits of the diameters of their orbits; for when a planet is in that point of its orbit which is nearest the Earth, it is evidently nearer by the whole diameter of its orbit, than when it is in the opposite point, on the other side of its orbit. The *apparent diameter* of the planet will also vary for the same reason, and to the same degree.

Mars is sometimes seen in opposition to the Sun, and sometimes in superior conjunction with him; sometimes gibbous, but never horned. In conjunction, it is never seen to pass over the Sun's disc, like Mercury and Venus. This proves not only that its orbit is *exterior* to the Earth's orbit, but that it is an opaque body, shining only by the reflection of the Sun.

The motion of Mars through the constellations of the zodiac is but little more than *half* as great as that of the Earth; it being generally about 57 days in passing over one sign, which is at the rate of a little more than half a degree each day. Thus, if we know what constellation Mars enters to-day, we may conclude that two months hence it will be in the next constellation; four months hence, in the next; six months, in the next, and so on.

Mars performs his revolution around the Sun in one year and $10\frac{1}{2}$ months, at the distance of 145 millions of miles; moving in its orbit at the mean rate of 55 thousand miles an hour. Its diurnal rotation on its axis is performed in 24 hours, 39 minutes, and $21\frac{1}{2}$ seconds; which makes its day about 44 minutes longer than ours.

Its mean *sidereal* revolution is performed in 686.9796458 solar days; or in 686 days, 23 hours, 30 minutes, 41.4 seconds. Its *synodical* revolution is performed in 779.936 solar days; or in 779 days, 22 hours, 27 minutes, and 50 seconds.

Its form is that of an oblate spheroid, whose polar diameter is to its equatorial, as 15 is to 16, nearly. Its diameter is 4222 miles. Its bulk, therefore, is 7 times less than that of the Earth; and being 50 millions of miles farther from the Sun, it receives from him only half as much light and heat.

The inclination of its axis to the plane of its orbit, is about

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Within what limits does the distance of all the planets from the Earth vary? With what does the apparent diameter of a planet vary? What moon-like phases has Mars? What does the fact, that it never assumes the crescent form at its conjunction, prove, in regard to its situation? How do we know it to be opaque? What is the rate of its motion through the constellations of the zodiac, compared with that of the Earth? How long is it in passing over one sign? At what rate per day is this? How, then, if we know in what constellation it is at any one time, may we determine in what constellation it will be at any subsequent time? In what time does it perform its revolution around the Sun? What is its distance from the Sun? What is the mean rate of its motion in its orbit per hour? In what time does it perform its revolution on its axis? What, then, is the length of its day, compared with that of the Earth? *In what time does it perform its mean sidereal revolution? In what time, its synodical revolution?* What are its form and dimensions?

$28\frac{3}{4}°$. Consequently, its seasons must be very similar to those of the Earth. Indeed, the analogy between Mars and the Earth is greater than the analogy between the Earth and any otner planet of the solar system. Their diurnal motion, and of course the length of their days and nights, are nearly the same; the obliquity of their ecliptics, on which the seasons depend, are not very different; and, of all the superior planets, the distance of Mars from the Sun is by far the nearest to that of the Earth; nor is the length of its year greatly different from ours, when compared with the years of Jupiter, Saturn, and Herschel.

To a spectator on this planet, the Earth will appear alternately, as a morning and evening star; and will exhibit all the phases of the Moon, just as Mercury and Venus do to us; and sometimes like them, will appear to pass over the Sun's disc like a dark round spot. Our Moon will never appear more than *a quarter of a degree* from the Earth, although her distance from it is 240,000 miles. If Mars be attended by a satellite, it is too small to be seen by the most powerful telescopes.

When it is considered that Vesta, the smallest of the asteroids, which is *once and a half* times the distance of Mars from us, and only 269 miles in diameter, is perceivable in the open space, and that without the presence of a more conspicuous body to point it out, we may reasonably conclude that Mars is without a moon.

The progress of Mars in the heavens, and indeed of all the superior planets, will, like Mercury and Venus, sometimes appear direct, sometimes retrograde, and sometimes he will seem stationary. When a superior planet first becomes visible in the morning, west of the Sun, a little after its conjunction, its motion is *direct*, and also most rapid. When it is first seen east of the Sun, in the evening, soon after its opposition, its motion is *retrograde*. These retrograde movements and stations, as they appear to a spectator from the Earth, are common to all the planets, and demonstrate the truth of the Copernican system.

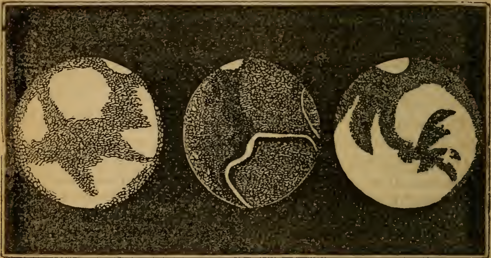
The telescopic phenomena of Mars afford peculiar interest to astronomers. They behold its disc diversified with numerous irregular and variable spots, and ornamented with zones and belts of varying brilliancy, that form, and disappear, by turns. Zones of intense brightness are to be seen in its polar regions, subject, however, to gradual changes. That of the southern pole is much the most brilliant. Dr. Herschel supposes that they are produced by the reflection of the Sun's light from the frozen regions, and that the melting of these masses of polar ice is the cause of the variation in their magnitude and appearance.

What, then, is its bulk, compared with the Earth's, and how much less light and heat does it receive from the Sun? What is the inclination of its axis to the plane of its orbit? How are its seasons, compared with those of the Earth? In what particulars is there a greater analogy between Mars and the Earth, than between the Earth and any other planet in the solar system? What must be the appearance of the Earth to a spectator at Mars? What is the greatest distance from the Earth at which our Moon will appear to him to be? *Why may we reasonably conclude that Mars has no satellite? Describe the progress of Mars through the heavens. What system do these retrograde movements and stations, common to all the planets as seen from the Earth, serve to establish?* What are the telescopic phenomena of Mars?

He was the more confirmed in these opinions by observing that after the exposure of the luminous zone about the north pole to a summer of eight months, it was considerably *decreased*, while that on the south pole, which had been in total darkness during eight months, had considerably *increased.*

He observed, farther, that when this spot was most luminous, the disc of Mars did not appear exactly *round*, and that the bright part of its southern limb seemed to be swollen or arched out beyond the proper curve.

TELESCOPIC APPEARANCES OF MARS.



The extraordinary height and density of the atmosphere of Mars, are supposed to be the cause of the remarkable redness of its light.

It has been found by experiment, that when a beam of white light passes through any colorless transparent medium, its color inclines to red, in proportion to the density of the medium, and the space through which it has traveled. Thus the Sun, Moon, and stars, appear of a reddish color when near the horizon; and every luminous object, seen through a mist, is of a ruddy hue.

This phenomenon may be thus explained:—The momentum of the red, or least refrangible rays, being greater than that of the violet, or most refrangible rays, the former will make their way through the resisting medium, while the latter are either reflected or absorbed. The color of the *beam*, therefore, when it reaches the eye, must partake of the color of the least refrangible rays, and this color must increase with the distance. The dim light, therefore, by which Mars is illuminated, having to pass *twice* through its atmosphere before it reaches the Earth, must be deprived of a great proportion of its violet rays, and consequently then be red. Dr. Brewster supposes that the difference of color among the other planets, and even the fixed stars, is owing to the different heights and densities of their atmospheres.

How does Dr. Herschel account for them? How may the remarkable redness of the light of Mars be accounted for?

THE ASTEROIDS, OR TELESCOPIC PLANETS.

Ascending higher in the solar system, we find, between the orbits of Mars and Jupiter, a cluster of ten small planets, which present a variety of anomalies that distinguish them from all the older planets of the system. Their names are *Vesta, Juno, Ceres, Pallas, Astrea, Hebe, Iris, Flora, Metis,* and *Hygiea.* These have all been discovered during the present century.

The dates of their discovery, and the names of their discoverers, are as follows:—

Ceres, January 1, 1801, by M. Piazzi, of Palermo.
Pallas, March 28, 1802. by M. Olbers, of Bremen.
Juno, September 1. 1804, by M. Harding, of Bremen.
Vesta, March 29, 1807, by M. Olbers, of Bremen.
Astrea, December 8, 1845, by Hencke, of Dresden.
Hebe, July 5, 1847, " " "
Iris, August 13, 1847, by Hind, of London.
Flora, October 18th. 1847, " "
Metis, April 25th, 1848, by Graham, of Sligo.
Hygiea, April 12, 1849, by Gasporis, of Naples.

The scientific Bode* entertained the opinion, that the planetary distances, above Mercury, formed a geometrical series, each exterior orbit being double the distance of its next interior one, from the Sun; a fact which obtains with remarkable exactness between Jupiter, Saturn, and Herschel. But this law seemed to be interrupted between Mars and Jupiter. Hence he inferred, that there was a planet wanting in that interval; which is now happily supplied by the discovery of the ten *star-form* planets, occupying the very space where the unexplained vacancy presented a strong objection to his theory.

These bodies are *much smaller* in size than the older planets—they all revolve *at nearly the same distances* from the Sun, and perform their revolutions in *nearly the same periods*—their orbits are much *more eccentric*, and have a *much greater inclination* to the ecliptic—and what is altogether singular, except in the case of comets—*all cross each other;* so that there is even a *possibility* that two of these

* According to him, the distances of the planets may be expressed nearly as follows: the Earth's distance from the Sun being 10.

Mercury	4	$= 4$	Asteroids	$4+3\times2^3$	$=$	28
Venus	$4+3\times1$	$= 7$	Jupiter	$4+3\times2^4$	$=$	52
The Earth	$4+3\times2$	$= 10$	Saturn	$4+3\times2^5$	$=$	100
Mars	$4+3\times2^2$	$= 16$	Herschel	$4+3\times2^6$	$=$	196

Comparing these values with the actual mean distances of the planets from the Sun, we cannot but remark the near agreement, and can scarcely hesitate to pronounce that the respective distances of the planets from the Sun, were assigned according to a law, although we are entirely ignorant of the exact law, and of the reason for that law.—*Brinkley's Elements*, p. 89.

What new planets have been discovered within the present century? Where are they situated? *What are the dates of their discovery, and the names of their discoverers?* Why did Bode infer that there was a planet wanting between Mars and Jupiter?

bodies may, some time, in the course of their revolutions, come into collision.

The orbit of Vesta is so eccentric, that she is sometimes farther from the Sun than either Ceres, Pallas, or Juno, although her mean distance is many millions of miles less than theirs. The orbit of Vesta crosses the orbits of all the other three, in two opposite points.

The student should here refer to the Figures, Plate 1 *of the Atlas, and verify such of these particulars as are there represented. It would be well for the teacher to require him to observe particularly the positions of their orbits, and to state their different degrees of inclination to the plane of the ecliptic.*

From these and other circumstances, many eminent astronomers are of opinion, that these ten planets are the fragments of a large celestial body which once revolved between Mars and Jupiter, and which burst asunder by some tremendous convulsion, or some external violence. The discovery of Ceres by Piazzi, on the first day of the present century, drew the attention of all the astronomers of the age to that region of the sky, and every inch of it was minutely explored. The consequence was, that, in the year following, Dr. Olbers, of Bremen, announced to the world the discovery of Pallas, situated not many degrees from Ceres, and very much resembling it in size.

From this discovery, Dr. Olbers first conceived the idea that these bodies might be the fragments of a former world; and if so, that other portions of it might be found either in the same neighborhood, or else, having diverged from the same point, "they ought to have two common points of reunion, or two nodes in opposite regions of the heavens through which all the planetary fragments must sooner or later pass."

One of these nodes he found to be in the constellation Virgo, and the opposite one, in the Whale; and it is a remarkable coincidence that it was in the neighborhood of the latter constellation that Mr. Harding discovered the planet Juno. In order therefore to detect the remaining fragments, if any existed, Dr. Olbers examined, three times every year, all the small stars in Virgo and the Whale; and it was actually in the constellation Virgo, that he discovered the planet Vesta. Some astronomers think it not unlikely that still additional fragments of a similar description may hereafter be discovered. Dr. Brewster attributes

In what particulars do these new planets differ from the older planets? How is it possible that two of them should ever come into collision? How is it that Vesta is sometimes farther from the Sun than either Ceres, Pallas, or Juno, when her mean distance is many millions of miles less than theirs? What is the position of her orbit with regard to their orbits? What theory in regard to the origin of these planets have some astronomers derived from these and some other circumstances? Who first conceived this idea? How came he to have this idea? Where did he imagine other fragments might be found? In what constellations did he find these nodes to be? Where were the planets Juno and Vesta actually found? How did Dr. Olbers discover Vesta?

the fall of meteoric stones to the smaller fragments of these bodies happening to come within the sphere of the Earth's attraction.

Meteoric stones, or what are generally termed *aerolites*, are stones which sometimes fall from the upper regions of the atmosphere upon the Earth. The substance of which they are composed, is, for the most part, *metallic;* but the ore of which it consists is not to found *in the same constituent proportions* in any known substance upon the Earth. Their fall is generally preceded by a luminous appearance, a hissing noise, and a loud explosion; and when found immediately after their descent, they are always hot, and usually covered with a black crust, indicating a state of exterior fusion.

Their size varies from that of small fragments of inconsiderable weight, to that of the most ponderous masses. They have been found to weigh from 300 pounds to several tons; and they have descended to the earth with a force sufficient to bury them many feet under the surface.

Some have supposed that they are projected from volcanoes in the Moon; others that they proceed from volcanoes on the Earth; while others imagine that they are generated in the regions of the atmosphere; but the truth probably is not yet ascertained. In some instances, these stones have penetrated through the roofs of houses, and proved destructive to the inhabitants.

If we carefully compute the force of gravity in the Moon, we shall find that if a body were projected from her surface with a momentum that would cause it to move at the rate of 8,200 feet in the first second of time, and in the direction of a line joining the centers of the Earth and Moon, it would not fall again to the surface of the Moon; but would become a satellite to the Earth. Such an impulse might, indeed, cause it, even after many revolutions, to fall to the Earth. The fall, therefore, of these stones, from the air, may be accounted for in this manner.

Mr. Harte calculates, that even a velocity of 6000 feet in a second, would be sufficient to carry a body projected from the surface of the Moon beyond the power of her attraction. If so, a projectile force three times greater than that of a cannon, would carry a body from the Moon, beyond the point of equal attraction, and cause it to reach the Earth. A force equal to this is often exerted by our volcanoes, and by subterranean steam. Hence, there is no impossibility in the supposition of their coming from the Moon; but yet I think the theory of aerial consolidation the more plausible.

Vesta appears like a star of the 5th or 6th magnitude, shining with a pure steady radiance, and is the only one of the asteroids which can be discerned by the naked eye.

JUNO revolves around the Sun in 4 years, 4½ months, at the mean distance of 254 millions of miles, moving in her orbit at the rate of 41 thousand miles an hour. Her diameter is estimated at 1393 miles. This would make her magnitude 183 times less than the Earth's. The light and heat which she receives from the Sun, is seven times less than that received by the Earth.

The eccentricity of her orbit is so great, that her greatest distance from the Sun is nearly double her least distance;

To what does Dr. Brewster attribute the fall of meteoric stones? *What is meant by the expression, meteoric stones? Of what substance are they composed? In what respect do they differ from any metallic substances known on the Earth? What indications generally precede their fall? In what state are they found to be after their descent? What is their magnitude? What theories have been adopted to account for their origin? Explain how it is not impossible that they may come from the Moon.* Describe the appearance of Vesta.

What is the planet next in order after Vesta? In what time does she complete her revolution around the Sun? What is her mean distance from him? What the rate of her motion per hour? What is the length of her diameter? How much less, then, is her magnitude, than that of the Earth? How much light and heat does she receive from the Sun, compared with those received by the Earth? How much greater is her greatest distance from the Sun, than her least distance?

so that, when she is in her *perihelion*, she is nearer the Sun by 130 millions of miles, than when she is in her *aphelion*. This great eccentricity has a corresponding effect upon her rate of motion; for being so much nearer, and therefore so much more powerfully attracted by the Sun at one time than at another, she moves through that half of her orbit which is nearest the Sun, in one half of the time that she occupies in completing the other half.

According to Schroeter, the diameter of Juno is 1425 miles; and she is surrounded by an atmosphere more dense than that of any of the other planets. Schroeter also remarks, that the variation in her brilliancy is chiefly owing to certain changes in the density of her atmosphere; at the same time he thinks it not improbable that these changes may arise from a diurnal revolution on her axis.

CERES revolves about the Sun in 4 years, 7⅓ months, at the mean distance of 263½ millions of miles, moving in her orbit at the rate of 41 thousand miles an hour. Her diameter is estimated at 1582 miles, which makes her magnitude 125 times less than the Earth's. The intensity of the light and heat which she receives from the Sun, is about 7½ times less than that of those received by the Earth.

Ceres shines with a ruddy color, and appears to be only about the size of a star of the eighth magnitude. Consequently she is never seen by the naked eye. She is surrounded by a species of cloudy or nebulous light, which gives her somewhat the appearance of a comet, forming, according to Schroeter, an atmosphere 675 miles in height.

Ceres, as has been said, was the first discovered of the asteriods. At her discovery, astronomers congratulated themselves upon the harmony of the system being restored. They had long wanted a planet to fill up the great void between Mars and Jupiter, in order to make the system complete in their own eyes; but the successive discoveries of Pallas and Juno again introduced confusion, and presented a difficulty which they were unable to solve, till Dr. Olbers suggested the idea that these small anomalous bodies were merely the fragments of a larger planet, which had been exploded by some mighty convulsion. Among the most able and decided advocates of this hypothesis, is Dr. Brewster, of Edinburgh.

PALLAS performs her revolution around the Sun in 4 years, 7⅗ months, at the mean distance of 264 millions of miles, moving in her orbit at the rate of 41 thousand miles an hour.

How much less time does she occupy in moving through that half of her orbit nearest to the Sun, than in moving through that which is farthest from him? *What is her diameter according to Schroeter? According to the same astronomer what is the density of her atmosphere, compared with that of the other planets? To what does he attribute the variation in her brilliancy?* What is the next planet in order after Juno? In what time does she complete her revolution about the Sun? What is her mean distance from him? What is the rate of her motion per hour! What is her diameter? How great is her magnitude, compared with that of the Earth? What is the intensity of the light and heat which she receives from the Sun, compared with that of those received by the Earth? Describe her appearance.

How high, according to Schroeter, is the atmosphere formed by this nebulous light? *Why did astronomers congratulate themselves on the discovery of this planet? What again introduced confusion and difficulty into their system? How were they at length enabled to solve the difficulty?* What planet is the next in order after Ceres? In what time does she complete her revolution around the Sun? What is her mean distance from him? What is the rate of her motion in her orbit per hour? What is her diameter?

Her diameter is estimated at 2025 miles, which is but little less than that of our Moon. It is a singular and very remarkable phenomenon in the solar system, that two planets, (Ceres and Pallas,) nearly of the same size, should be situated at equal distances from the Sun, revolve about him in the same period, and in orbits that intersect each other. The difference in the respective distances of Ceres and Pallas is less than a million of miles. The difference in their sidereal revolutions, according to some astronomers, is but a single day!

The following table exhibits the order of the Asteroids, beginning at the Sun; the inclination of their orbits to the plane of the ecliptic and their periodic time:

	Names.	Inclination.*			Ys.	Days
1.	Flora,	5°	52′	55″	3	98
2.	Vesta,	7	08	30	3	230
3.	Iris,	5	28	10	3	250
4.	Metis,	5	25	34	3	251
5.	Hebe,	14	44	25	3	280
6.	Astrea,	5	19	17	4	50
7.	Juno,	13	02	39	4	134
8.	Ceres,	10	37	13	4	220
9.	Pallas,	34	37	31	4	225
10.	Hygiea, not determined.					

The calculation of the latitude and longitude of the asteroids is a labor of extreme difficulty, requiring more than 400 equations to reduce their anomalous perturbations to the true place. This arises from the want of auxiliary tables, and from the fact that the elements of the star-form planets, are very imperfectly determined. Whether any of the asteroids has a rotation on its axis, remains to be ascertained.

JUPITER.

JUPITER is the largest of all the planets belonging to the solar system. It may be readily distinguished from the fixed stars, by its peculiar splendor and magnitude; appearing to the naked eye almost as resplendent as Venus, although i is more than seven times her distance from the Sun.

When his right ascension is less than that of the Sun, he is our morning star, and appears in the eastern hemisphere

* See representation, Plate 1 of Atlas.

How great is it compared with the diameter of the Moon? What is the difference between the respective distances of Ceres and Pallas from the Sun? What is the difference between the times of their sidereal revolutions? *Why is the calculation of the latitude and longitude of the asteroids a labor of extreme difficulty? Have any of the asteroids rotations on their axes?* Which is the largest planet of the solar system? How may Jupiter be readily distinguished from the fixed stars? How much farther is he from the Sun than Venus? In what case is he our morning star?

before the Sun rises; when greater, he is our evening star, and lingers in the western hemisphere after the Sun sets.

Nothing can be easier than to trace Jupiter among the constellations of the zodiac; for in whatever constellation he is seen to-day, one year hence he will be seen equally advanced in the *next* constellation; two years hence, in the next; three years hence, in the next, and so on; being just a year, at a mean rate, in passing over one constellation.

The exact mean motion of Jupiter in its orbit, is about one-twelfth of a degree in a day; which amounts to only 30° 20′ 32″ in a year.

For 12 years to come, he will, at a mean rate, pass through the constellations of the zodiac, as follows:

1850, Leo,	1854, Sagittarius.	1858, Aries.
1851, Virgo.	1855, Capricornus,	1859, Taurus.
1852, Libra.	1856, Aquarius.	1860, Gemini.
1853, Scorpio.	1857, Pisces.	1861, Cancer

Jupiter is the next planet in the solar system above the asteroids, and performs his annual revolution around the Sun in nearly 12 of our years, at the mean distance of 495 millions of miles; moving in his orbit at the rate of 30,000 miles an hour.

The exact period of Jupiter's sidereal revolution is 11 years, 10 months. 17 days. 14 hours, 21 minutes, 25¼ seconds. His exact mean distance from the Sun is 495.533.837 miles; consequently, the exact rate of his motion in his orbit, is 29,943 miles per hour.

He revolves on an axis, which is perpendicular to the plane of his orbit, in 9 hours, 55 minutes, and 50 seconds; so that his year contains 10,471 days and nights; each about 5 hours long.

His form is that of an oblate spheroid, whose polar diameter is to its equatorial, as 13 to 14. He is therefore considerably more flattened at the poles, than any of the other planets, except Saturn. This is caused by his rapid rotation on his axis; for it is a universal law that the equatorial parts of every body, revolving on an axis, will be swollen out, in proportion to the density of the body, and the rapidity of its motion.

The difference between the polar and equatorial diameters of Jupiter, exceeds 6000 miles. The difference between the polar and equatorial diameters of the Earth, is only 26 miles. Jupiter, even on the most careless view through a good telescope, appears to be oval; the longer diameter being parallel to the direction of his belts, which are also parallel to the ecliptic.

In what our evening? How may he be traced among the constellations of the zodiac? In what constellation will he be, each year, for twelve years to come? What is his position in the solar system? What is his mean distance from the Sun? What is the rate per hour of his motion in his orbit? *What is the exact period of his sidereal revolution? What is his exact mean distance from the Sun? What the exact rate per hour of his motion in his orbit?* What is the position of his axis with respect to the plane of his orbit? How many days and nights does his year contain? How long are they each? What is his form? What is the ratio between his polar and equatorial diameters? What is the cause of his being more flattened at the poles than any of the other planets? *What is the difference between his polar and equatorial diameters? What does his form appear to be, through a good telescope? What is the direction of his longer diameter?*

By this rapid whirl on its axis, his equatorial inhabitants are carried around at the rate of 26,554 miles an hour; which is 1600 miles farther than the equatorial inhabitants of the Earth are carried, by its diurnal motion, in *twenty-four hours.*

The true *mean* diameter of Jupiter is 86,255 miles; which is nearly 11 times greater than the Earth's. His volume is therefore about *thirteen hundred* miles larger than that of the Earth. (*For magnitude as compared with that of the Earth, see Plate I.*) On account of his great distance from the Sun, the degree of light and heat which he receives from it, is 27 times *less* than that received by the Earth.

When Jupiter is in conjunction, he rises, sets, and comes to the meridian with the Sun; but is never observed to make a transit, or pass over the Sun's disc; when in opposition, he rises when the Sun sets, sets when the Sun rises, and comes to the meridian at midnight, which never happens in the case of an *interior* planet. This proves that Jupiter revolves in an orbit which is *exterior* to that of the Earth.

As the variety in the seasons of a planet, and in the length of its days and nights, depends upon the inclination of its axis to the plane of its orbit, and as the axis of Jupiter has no inclination, there can be no difference in his seasons, on the same parallels of latitude, nor any variation in the length of his days and nights. It is not to be understood, however, that *one uniform season* prevails from his equator to his poles; but that the *same parallels of latitude* on each side of his equator, uniformly enjoy the same season, whatever season it may be.

About his equatorial regions there is perpetual summer; and at his poles everlasting winter; but yet equal day and equal night at each. This arrangement seems to have been kindly ordered by the beneficent Creator; for had his axis been inclined to his orbit, like that of the Earth, his polar winters would have been alternately a dreadful night of *six years darkness.*

Jupiter when viewed through a telescope, appears to be surrounded by a number of luminous zones, usually termed *belts*, that frequently extend quite around him. These belts are parallel not only to each other, but, in general, to his equator, which is also nearly parallel to the ecliptic. They are subject, however, to considerable variation, both in

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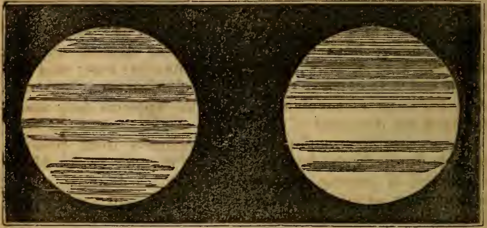
At what rate per hour are his equatorial inhabitants carried by his motion on his axis? How much farther is this than the equatorial inhabitants of the Earth are carried in 24 hours? What is Jupiter's true mean diameter? How much greater is it than the Earth's? What is his volume, compared with the Earth's? What is the degree of light and heat which he receives from the Sun, compared with that received by the Earth? *How do we know that Jupiter's orbit is exterior to that of the Earth?* What is the arrangement of Jupiter's seasons, and of his days and nights? Had his axis been inclined to the plane of his orbit, like that of our Earth, how long would his polar nights have been? Describe Jupiter's appearance, as seen through a telescope. What is supposed to be the cause of these phenomena breadth and number. Sometimes eight have been seen at once; sometimes only one, but more usually three. Dr. Herschel once perceived his whole disc covered with small belts, though they are more usually confined to within 30° of his equator, that is, to a zone 60° in width.

TELESCOPIC APPEARANCES OF JUPITER.



Sometimes these belts continue for months at a time with little or no variation, and sometimes a new belt has been seen to form in a few hours. Sometimes they are interrupted in their length; and at other times, they appear to spread in width, and run into each other, until their breadth exceeds 5,000 miles.

Bright and dark spots are also frequently to be seen in the belts, which usually disappear with the belts themselves, though not always, for Cassini observed that one occupied the same position more than 40 years. Of the *cause* of these variable appearances, but little is known. They are generally supposed to be nothing more than *atmospherical phenomena*, resulting from, or combined with, the rapid motion of the planet upon its axis.

Different opinions have been entertained by astronomers respecting the cause of these belts and spots. By some they have been regarded as clouds, or as openings in the atmosphere of the planet, while others imagine that they are of a more permanent nature, and are the marks of great physical revolutions, which are perpetually agitating and changing the surface of the planet. The first of these opinions sufficiently explains the variations in the form and magnitude of the *spots*, and the *parallelism* of the belts. The spot first observed by Cassini, in 1665, which has both disappeared and re-appeared in the same form and position for the space of 43 years, could not possibly be occasioned by any atmospherical variations, but seems evidently to be connected with the surface of the planet. The form of the belt, according to some astronomers, may be accounted for by supposing that the *atmosphere* reflects more light than the *body* of the planet, and that the clouds which float in it, being thrown into parallel strata by the rapidity of its diurnal motion, form regular *interstices*, through which are seen its opaque body, or any of the permanent spots which may come within the range of the opening.

Relate some of the different opinions entertained by astronomers on this subject. How many satellites has Jupiter? How often are they visible to him? What is the distance from him of his first or nearest satellite? What is the time of its revolution?

Jupiter is also attended by four satellites or moons, some of which are visible to him every hour of the night; exhibiting, on a small scale and in short periods, most of the phenomena of the solar system. When viewed through a telescope, these satellites present a most interesting and beautiful appearance. The first satellite, or that nearest the planet, is 259,000 miles distant from its center, and revolves round it in 42½ hours; and appears, at the surface of Jupiter, four times larger than our Moon does to us. His second satellite, being both smaller and farther distant, appears about the size of ours; the third, somewhat less; and the fourth, which is more than a million of miles from him, and takes 16¾ days to revolve around him, appears only about *one third* the diameter of our Moon.

These satellites suffer frequent eclipses from passing through Jupiter's shadow, in the same manner as our Moon is eclipsed in passing through the Earth's shadow. The three nearest satellites fall into his shadow, and are eclipsed in every revolution; but the orbit of the fourth is so much inclined, that it passes by its opposition to him, two years in six, without falling into his shadow. By means of these eclipses, astronomers have not only discovered that light is 8 minutes and 13 seconds in coming to us from the Sun, but are also enabled to determine the longitude of places on the Earth with greater facility and exactness than by any other methods yet known.

It was long since found, by the most careful observations, that when the Earth is in that part of her orbit which is nearest to Jupiter, the eclipses appear to happen 8′ 13″ *sooner* than the tables predict; and when in that part of her orbit which is farthest from him, 8′ 13″ *later* than the tables predict; making a total difference in time, of 16′ 26″. From the mean of 6000 eclipses observed by Delambre, this disagreement between *observation* and *calculation*, was satisfactorily settled at 8′ 13″, while both were considered equally correct. Now when the eclipses happen *sooner* than the tables. Jupiter is at his nearest approach to the Earth—when *later*, at his greatest distance; so that the difference in his distances from the Earth, in the two cases, is the *whole diameter of the Earth's orbit*, or about 190 millions of miles. Hence, it is concluded that light *is not instantaneous*, but that it occupies 16′ 26″ in passing across the Earth's orbit. or 8′ 13″ in coming from the Sun to the Earth; being nearly 12 millions of miles a minute.

The revolutions of the satellites about Jupiter are precisely similar to the revolutions of the planets about the Sun. In this respect they are an epitome of the solar system, exhibiting, on a smaller scale, the various changes that take place among the planetary worlds.

What is its apparent magnitude at the surface of Jupiter, compared with the magnitude of the Moon, as seen by us? What are the apparent magnitudes of his other satellites as seen at his surface, compared with that of the Moon as seen at the Earth? What is the distance of his fourth satellite from him? What is the time of its revolution? How often are his three nearest satellites eclipsed? How often his fourth? Why is it not eclipsed as often as the others? What important purposes have these eclipses served to astronomers? *State the method by which the progressive motion of light, and the time which it occupies in coming to us from the Sun, were discovered.*

Jupiter, when seen from his nearest satellite, appears a *thousand times larger* than our Moon does to us, exhibiting on a scale of inconceivable magnificence, the varying forms of a crescent, a half moon, a gibbous phase, and a full moon, every 42 hours.

The apparent diameters of Jupiter's satellites, their mean distances from him, and their periodical revolutions, are exhibited in the following table.

Satellites.	Revolution.			App. Diam.	Mean Distance.
First,	1d.	18h.	28m.	1. 667	259,000
Second,	3	13	14	1. 189	414,000
Third,	7	3	43	1. 050	647,000
Fourth,	16	16	32	0. 550	1,164.000

In passing across the disc of Jupiter, one of his satellites has been known to lose all its light, as if undergoing eclipse, until it finally became a *black* spot on the disc of the planet; after passing off the disc it resumed its light.—*Prof. Mitchel.*

SATURN.

Saturn is situated between the orbits of Jupiter and Herschel, and is distinctly visible to the naked eye. It may be easily distinguished from the fixed stars by its pale, feeble, and steady light. It resembles the star Fomalhaut, both in color and size, differing from it only in the steadiness and uniformity of its light.

From the slowness of its motion in its orbit, the pupil throughout the period of his whole life, may trace its apparent course among the stars, without any danger of mistake. Having once found when it enters a particular constellation, he may easily remember where he is to look for it in any subsequent year; because, at a mean rate, it is just 2½ years in passing over a single sign or constellation.

Saturn's mean daily motion among the stars is only about 2′, the *thirtieth part of a degree.*

Saturn entered the constellation Virgo about the beginning of 1833, and continued in it until the middle of the year 1835, when he passed into Libra. He continued in that constellation until 1838; and so on, occupying about 2½ years in each constellation, or nearly 30 years in one revolution. At this date, (1849) he is in the constellation Pisces.

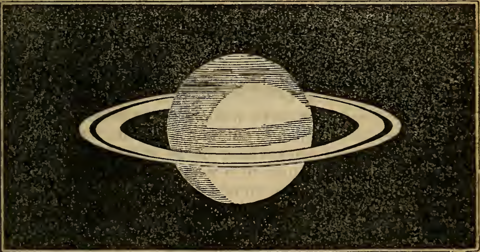
In what respect are Jupiter's satellites an epitome of the solar system? What is Jupiter's appearance, as seen from his nearest satellite? *What are the diameters, mean distances, and times of the revolution of his satellites?* Where, in the solar system, is Saturn situated? How may it be distinguished from the fixed stars? What star does it resemble? In what respects is it like it, and in what is it different from it? How may his place among the stars be readily found? What is about the rate of his mean daily motion among the stars? *When did Saturn enter the constellation Virgo, and how long did he continue in it? What constellation did he enter next, and how long did he continue in it? Where is he at this date?*

The mean distance of Saturn from the Sun is nearly double that of Jupiter, being about 909 millions of miles. His diameter is about 82,000 miles; his volume therefore is *eleven hundred times* greater than the Earth's. Moving in his orbit at the rate of 22,000 miles an hour, he requires 29½ years to complete his circuit around the Sun: but his diurnal rotation on his axis is accomplished in 10½ hours. His year, therefore, is nearly thirty times as long as ours, while his day is shorter by more than one half. His year contains about 25,150 of its own days, which are equal to 10,759 of our days.

The surface of Saturn, like that of Jupiter, is diversified with belts and dark spots. Dr. Herschel sometimes perceived five belts on his surface; three of which were dark, and two bright. The dark belts have a yellowish tinge, and generally cover a broader zone of the planet than those of Jupiter.

To the inhabitants of Saturn, the Sun appears 90 times less than he appears to the Earth; and they receive from him only one *ninetieth part* as much light and heat. But it is computed that even the *ninetieth* part of the Sun's light exceeds the illuminating power of 3,000 full moons, which would be abundantly sufficient for all the purposes of life.

TELESCOPIC VIEW OF SATURN.



The telescopic appearance of Saturn is unparalleled. It is even more interesting than Jupiter, with all his moons and

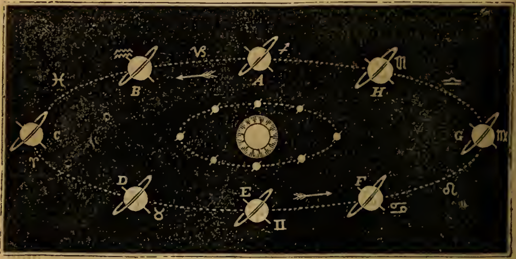
How long time does he occupy in passing through each constellation, and what is the length of his year? What is his distance from the Sun? How much greater is this than Jupiter's distance? What is his diameter? How much greater is his volume than that of the Earth? What is the rate per hour of his motion in his orbit? In what time is his diurnal motion on his axis performed? How many of his own days does his year contain, and how many of ours? What is the appearance of his surface to us? How many belts did Dr. Herschel perceive on his surface? Describe them. How much less does the Sun appear to the inhabitants of Saturn than to us? What degree of light and heat does he receive from the Sun, compared with that received by the Earth? To the light of how many full moons is this degree of light equal? Describe the telescopic appearance of Saturn.

belts. That which eminently distinguishes this planet from every other in the system, is a magnificent zone or ring, encircling it with perpetual light.

The light of the ring is more brilliant than the planet itself. It turns around its center of motion in the same time that Saturn turns on its axis. When viewed with a good telescope, it is usually found to consist of two concentric rings, divided by a dark band.

It has been ascertained, however, that these rings are again subdivided; the third division was distinctly seen by Prof. Encke, on the 25th of April, 1837, and also by Mr. Lassell, on the 7th of September, 1843, at his observatory near Liverpool, England. Six different rings were seen at Rome, in Italy, on the night of the 29th of May, 1838.

SATURN IN HIS ORBIT.

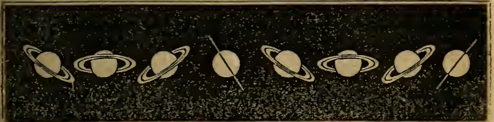


The above is a representation of Saturn in his orbit, as he would appear to one at a distance from the solar system, who could take in his whole orbit at one view, and watch him through his entire revolution. A and E, are the *equinoctial*, and C and G, the solstitial points. At the former, the Sun shines *edgewise* upon and *crosses* the rings; so that they are nearly or quite invisible. At C and G, the planet is most favorably situated for observing his rings from the Earth. From C around to E, the Sun shines upon the *south side*, of the rings, and from E to C again upon the *north side*. The Earth is seen in her proper place much nearer the Sun.

By the laws of mechanics, it is impossible that the body of the rings should retain its position by the adhesion of the particles alone; it must necessarily revolve with a velocity that will generate centrifugal force sufficient to balance the attraction of Saturn. Observation confirms the truth of these principles, showing that the rings rotate about the planet in 10½ hours, which is considerably less than the time a satellite would take to revolve about it at the same distance. Their plane is inclined to the ecliptic in an angle of 31°. In conseqence of this obliquity of position, they always appear elliptical to us, but with an eccentricity so variable as to appear, occasionally, like a straight line drawn across the planet; in which case they are visible only by the aid of superior instruments. Such was their position in April, 1833; for the Sun was then passing from their south to their north side. The rings intersect the ecliptic in two opposite points, which may be called their nodes. These points are in longitude 170°, and 350 degrees. When, therefore, Saturn is in either of these points, his rings will be invisible to us. On the contrary, when his longitude is 80°, or 200°, the rings may be seen to the greatest advantage. As the edge of the rings will present themselves to the Sun twice in each revolution of the planet, it is obvious that the disappearance of them will occur once in about 15 years; subject, however, to the variation dependent on the position of the Earth at that time.

But it must also be obvious that to an observer upon the Earth, the rings would present a great variety of aspects, during the thirty years of the planet's revolution; this is actually the case. The following cut will illustrate the appearances of the rings, at different times during the thirty years of his periodic revolution.

TELESCOPIC PHASES OF SATURN.



The distance between Saturn and his inner ring, is only 21,000 miles; being less than a *tenth part* of the distance of our Moon from the Earth. The breadth of the dark band, or the interval between the rings, is hardly 3,000 miles. The breadth of the inner ring is 20,000 miles. Being only about the same distance from Saturn, it will present to his inhabitants a luminous zone, arching the whole concave vault from one hemisphere to the other with a broad girdle of light.

The most obvious use of this double ring is, to reflect light upon the planet in the absence of the Sun; what other purposes it may be intended to subserve, is to us unknown. The Sun, as has been shown, illuminates one side of it during 15 years, or one half of the period of the planet's revolution;

What is the longitude of these nodes? In what position of Saturn, then, will the rings be invisible to us, and in what position will they be seen to the best advantage? How often will the disappearance of the rings occur? Explain this. In what signs will the planet be when the Sun shines on the south side of the rings, and in what on the north side? What is the distance between Saturn and his inner ring? How great is this, compared with the distance of our Moon from the Earth? What is the distance between the two rings? What is the breadth of the inner ring? What must be its appearance at Saturn? What is the most obvious use of this double ring? How long a time does the Sun enlighten each side of it alternately? How often and in what circumstances is neither side enlightened, and the ring, of course, invisible?

and, during the next 15 years, the other side is enlightened in its turn.

Twice in the course of 30 years, there is a short interval of time when neither side is enlightened, and when, of course it ceases to be visible; namely, at the time when the Sun ceases to shine on one side, and is about to shine on the other. It revolves around its axis, and consequently, around Saturn, in 10½ hours, which is at the rate of a thousand miles in a minute, or 58 times swifter than the revolution of the Earth's equator.

When viewed from the middle zone of the planet, in the absence of the Sun, the rings will appear like vast luminous arches, extending along the canopy of heaven, from the eastern to the western horizon, exceeding in breadth a hundred times the apparent diameter of our Moon.

Besides the rings, Saturn is attended by eight satellites, which revolve about him at different periods and distances, and reciprocally reflect the Sun's rays on each other and on the planet. The rings and moons illuminate the nights of Saturn; the moons and Saturn enlighten the rings, and the planet and rings reflect the Sun's beams on the satellites.

The *fourth* of these satellites (in the order of their distance) was *first* discovered by Huygens, on the 25th of March, 1655, and in honor of the discoverer, was called the *Huigenian Satellite*. This satellite being the largest of all, is seen without much difficulty. Cassini discovered the 1st, 2d, 3d, and 5th satellites, between October, 1671, and March, 1684. Dr. Herschel discovered the 6th and 7th in 1789. These are nearer to Saturn than any of the rest, though, to avoid confusion, they are named in the order of their discovery.

The sixth and seventh are the smallest of the whole; the first and second are the next smallest; the third is greater than the first and second; the fourth is the largest of them all; and the fifth surpasses the rest in brightness.

Their respective distances from their primary, vary from half the distance of our Moon, to two millions of miles. Their periodic revolutions vary from 1 day to 79 days. The orbits of the six inner satellites, that is, the 1st, 2d, 3d, 4th, 6th, and 7th, all lie in the plane of Saturn's rings, and revolve around their outer edge; while the 5th satellite deviates so far from the plane of the rings, as sometimes to be seen *through the opening* between them and the planet. Of the 8th satellite recently discovered, we have as yet much less knowledge than of its predecessors.

In what time does the ring complete its revolution on its axis, and, of course, around the planet? What is the rate per minute of its motion? How rapid is this, compared with the motion of the Earth's equator? What would be the appearance of the rings, if viewed from the middle zone of the planet, in the absence of the Sun? How many moons has Saturn? How are Saturn, his rings and satellites, severally, enlightened? *What are the dates of their discovery, and the names of their discoverers?* What are their comparative magnitudes, distances, and times of revolution? What is the position of their orbits with respect to the rings of Saturn? *What does Laplace imagine retains the orbits of Saturn's first six satellites in the plane of his equator?*

Laplace imagines that the accumulation of matter at Saturn's equator retains the orbits of the first six satellites in the plane of the equator, in the same manner as it retains the rings in that plane. It has been satisfactorily ascertained, that Saturn has a greater accumulation of matter about his equator, and consequently that he is more flattened at the poles, than Jupiter, though the velocity of the equatorial parts of the former is much less than that of the latter. This is sufficiently accounted for by the fact, that the *rings* of Saturn lie in the plane of his equator, and act more powerfully upon those parts of his surface than upon any other; and thus, while they aid in diminishing the gravity of these parts, also aid the centrifugal force in flattening the poles of the planet. Indeed, had Saturn never revolved upon his axis, the action of the rings would, of itself, have been sufficient to give him the form of an oblate spheroid.

The theory of the satellites of Saturn is less perfect than that of the satellites of Jupiter. The difficulty of observing their eclipses, and of measuring their elongations from their primary, have prevented astronomers from determining, with their usual precision, their mean distances and revolutions.

We may remark, with the Christian Philosopher, that there is no planet in the solar system, whose firmament presents such a variety of splendid and magnificent objects as that of Saturn.

The various aspects of the seven moons, one rising above the horizon, while another is setting, and a third approaching to the meridian; one entering into an eclipse, and another emerging from one; one appearing as a crescent, and another with a gibbous phase; and sometimes the whole of them shining in the same hemisphere, in one bright assemblage! The majestic motion of the rings—at one time illuminating the sky with their splendor, and eclipsing the stars; at another, casting a deep shade over certain regions of the planet, and unveiling to view the wonders of the starry firmament, are scenes worthy of the majesty of the Divine Being to unfold, and of rational creatures to contemplate.

Such displays of Wisdom and Omnipotence, lead us to conclude that the numerous splendid objects connected with this planet, were not created merely to shed their lustre on naked rocks and barren sands; but that an immense population of intelligent beings is placed in those regions, to enjoy the bounty, and adore the goodness, of their great Creator.

The following table exhibits the apparent and mean distances of the satellites from their primary (the 8th excepted). and the times of their periodical revolution. Their distances in *miles* were computed from their observed micrometer distances; the diameter of Saturn's *equator* being considered equal to 80.000 miles.

Why are astronomers less acquainted with the mean distances and revolutions of Saturn's satellites, than with those of Jupiter? Describe the firmament of Saturn, as illuminated by his rings and satellites.

Satellites.	Periodic revolution.			Distance in diameter.	Distance in miles.
1	0d.	22h.	38m.	1.540	123.200
2	1	8	53	1.976	158.080
3	1	21	18	2.447	195.720
4	2	17	45	3 134	250.720
5	4	12	25	4.377	350,160
6	15	22	41	10.143	811,400
7	79	7	55	29.577	2,366,160

HERSCHEL OR URANUS.

HERSCHEL is the next planet in order from the Sun, beyond or above Saturn. To the naked eye, it appears like a star of only the 6th or 7th magnitude, and of a pale, bluish white; but it can seldom be seen, except in a very fine, clear night, and in the absence of the Moon.

As it moves over but one degree of its orbit in 85 days, it will be *seven years* in passing over one sign or constellation.

When first seen by Dr. Herschel, in 1781, it was in the foot of *Gemini ; so that it has not yet completed one revolution since it was first discovered to be a planet.*

It is remarkable that this body was observed as far back as 1690. It was seen three times by Flamstead, once by Bradley, once by Mayer, and eleven times by Lemonnier, who registered it among the stars; but not one of them suspected it to be a planet.

The inequalities in the motions of Jupiter and Saturn, which could not be accounted for from the mutual attractions of these planets, led astronomers to suppose that there existed another planet beyond the orbit of Saturn, by whose action these irregularities were produced. This conjecture was confirmed March 13th, 1781; when Dr. Herschel discovered the *motions* of this body, and thus proved it to be a planet.

Herschel is attended by six moons or satellites, which revolve about him in different periods, and at various distances. Four of them were discovered by Dr. Herschel, and two by his sister, Miss Caroline Herschel. It is possible that others remain yet to be discovered.

What is the relative distance of the planet Herschel from the Sun? What is its appearance to the naked eye? In what circumstances can it be seen? What is the rate of its motion in its orbit? What is its present position? What was its position when first discovered to be a planet? How much, then, of its revolution has been completed, since it was first discovered? *At how early a date was this body observed in the heavens? Who observed it, before it was discovered to be a planet? How many times was it seen by them, respectively? What did they consider it to be?* What led astronomers to suppose that there existed another planet beyond Saturn? When and by whom was Herschel discovered to be a planet? How many moons has it?

Herschel's mean distance from the Sun is 1828 millions of miles; more than twice the mean distance of Saturn. His sidereal revolution is performed in 84 years and 1 month, and his motion in his orbit is 15,600 miles an hour. He is supposed to have a rotation on his axis, in common with the other planets; but astronomers have not yet been able to obtain any ocular proof of such a motion.

His diameter is estimated at 34,000 miles; which would make his volume more than 80 times larger than the Earth's. To his inhabitants, the Sun appears only the $\frac{1}{368}$ part as large as he does to us; and of course they receive from him only that small proportion of light and heat. It may be shown, however, that the $\frac{1}{368}$ part of the Sun's light exceeds the illuminating power of 800 full Moons. This added to the light they must receive from their six satellites, will render their days and nights far from cheerless.

The distance from the planet and periodic times of the satellites of Herschel, respectively, are as follows:

	Dist. in miles.	Periodic Times. D.	H.	M.	S.
1.	224,000	5	21	25	20
2.	296,000	8	16	57	47
3.	340,000	10	23	02	47
4.	390,000	13	10	56	29
5.	777,000	38	01	48	00
6.	1,556,000	107	16	39	56

LEVERRIER OR NEPTUNE.

This is the most distant of the primary planets, and in some respects one of the most interesting. It is about 40,000 miles in diameter, is situated at the mean distance of 2,850,000,000 miles from the Sun, and revolves around him in 164 years. So remote is this newly-discovered member of the solar system, that for a body to reach it, moving at rail-road speed, or 30 miles an hour, would require more than *twenty thousand years!*

The circumstances of the *discovery* of this planet, are at

By whom were Herschel's satellites discovered? What is the distance of Herschel's orbit from the Sun? How much greater is this distance than that of Saturn? In what time is his sidereal revolution performed? What is the rate per hour of his motion in his orbit? Has he a rotation on his axis? What is his diameter estimated to be? How much larger would this make his volume than the Earth? How much less does the Sun appear to be to the inhabitants of Herschel, than he does to us? What degree of light and heat do they receive from him, compared with that received by the Earth? To the light of how many full moons is this degree of light equal? What is said of the *distance* and *magnitude* of Neptune? What is its periodic time?

once interesting and remarkable. Such is the regularity of the planetary motions, that astronomers are enabled to predict, with great accuracy, their future places in the heavens, and to construct tables, exhibiting their positions for ages to come. Soon after the discovery of Herschel, in 1781, his orbit was computed, and a table constructed for determining his future positions in the heavens, but instead of following the prescribed path, or occupying his estimated positions, he was found to be yielding to some mysterious and unaccountable influence, under which he was gradually leaving his computed orbit, and failing to meet the conditions of the tables.

At first this discrepancy between the observed and the estimated places of Herschel, was charged upon the *tables*, and a new orbit and new tables were computed, which it was thought could not fail to represent the future places of the planet. But these also seemed to be erroneous, as it was soon discovered that the computed and observed places did not agree, and the difference was becoming greater and greater every year. This was an anomaly in the movements of a planetary body. It was not strange that it should be subject to perturbations, from the attractive influence of the large planets Jupiter and Saturn, as these were known to act upon him, as well as upon each other, and the smaller planets, producing perturbations in their orbits, but all this had been taken into the account in constructing the tables, and still the planet deviated from its prescribed path. To charge the discrepancy to the *tables*, was no longer reasonable, though it was thought perhaps sufficient allowance had not been made, in their computation, for the disturbing influence of Jupiter and Saturn. To determine this question, M. Leverrier of Paris undertook a thorough discussion of the subject, and soon ascertained that the disturbing influence upon Herschel of all the known planets, was not sufficient to account for the anomalous perturbations already described, and that they were probably caused by some *unknown planet*, revolving beyond the orbit of Herschel. From the amount and effect of this disturbing influence from an unknown source, the distance, magnitude, and position of the imaginary planet were computed. At this stage of the investigation, Leverrier wrote to his friend, Dr. Galle, of Berlin, requesting him to direct his telescope to that part of

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How is its vast distance illustrated? Who discovered this planet and when? What circumstances led to its discovery, and how was it made? Who first *saw* the planet, and how near was it to its computed position? What other mathematician had computed its existence, period, &c? Why, then, was he not the discoverer? How many satellites has Neptune, and by whom discovered? What is said of the planet's being surrounded by rings? What reason have we to suppose that the different bodies of the solar system were created at the same time?

the heavens in which his calculations had located the new planet, when lo! there he lay *a thousand millions of miles beyond the orbit of Herschel*, and yet within less than one degree of the *place* pointed out by Leverrier! This was on the first of September, 1846.

While M. Leverrier was engaged in his calculations at Paris, Mr. Adams, a young mathematician of Cambridge, England, was discussing the same great problem, and had arrived at similar results even before M. Leverrier, though entirely ignorant of each other's labors or conclusions. This seems to establish the fact, that the new planet was discovered by calculation, though the failure of Mr. Adams to publish his conclusions, cut off his right to the honor of the discovery.

Since the discovery of this planet, it has been ascertained that it was seen as far back as 1795, though supposed to be a fixed star, and catalogued as such, and that all the irregularities of Herschel, with which astronomers were so much perplexed, are perfectly accounted for by the influence of the new planet.

On the 12th of October, 1846, Mr. Lassell of Starfield, near Liverpool, discovered a satellite attendant upon Leverrier, and also, as he supposes, one or more *rings* similar to those of Saturn; but though the secondary has often been seen by others since, and has been made the basis of elaborate calculations respecting the mass of the primary, no further discovery of the rings has been made by any other observer.

Such is the celestial system with which our Earth was associated at its creation, distinct from the rest of the starry hosts. Whatever may be the comparative antiquity of our globe, and the myriads of radiant bodies which nightly gem the immense vault above us, it is most reasonable to conclude, that the Sun, Earth, and planets, differ little in the date of their origin.

This fact, at least, seems to be philosophically certain, that all the bodies which compose our solar system must have been placed at one and the same time in that arrangement, and in those positions in which we now behold them; because all maintain their present stations, and motions, and distances, *by their mutual action on each other*. Neither could it be where it is, nor move as it does, nor appear as we see it unless they were all co-existent. The presence of each is essential to the system—the Sun to them, they to the Sun, and all to each other. This fact is a strong indication that their formation was simultaneous.

COMETS.

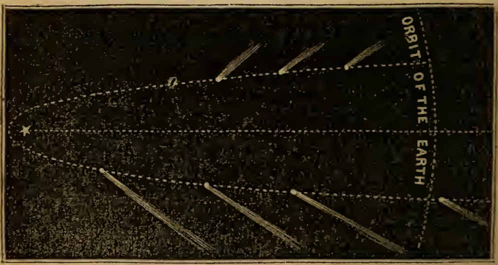
Comets, whether viewed as ephemeral meteors, or as substantial bodies, forming a part of the solar system, are objects of no ordinary interest.

When, with uninstructed gaze, we look upwards, to the clear sky of evening, and behold, among the multitudes of heavenly bodies, one, blazing with its long train of light, and rushing onward towards the center of our system, we insensibly shrink back as if in the presence of a supernatural being.

But when, with the eye of astronomy, we follow it through its perihelion, and trace it far off, beyond the utmost verge of the solar system, till it is lost in the infinity of space, not to return for centuries, we are deeply impressed with a sense of that power which could create and set in motion such bodies.

Comets are distinguished from the other heavenly bodies, by their appearance and motion. The appearance of the planets is globular, and their motion around the Sun is nearly in the same plane, and from west to east; but the comets have a variety of forms, and their orbits are not confined to any particular part of the heavens; nor do they observe any one general direction.

ORBIT OF A COMET.



The orbits of the planets approach nearly to circles, while those of the comets are very elongated ellipses. A wire hoop, for example, will represent the orbit of a planet. If

What feelings does the contemplation of comets naturally excite? How are comets distinguished from the other heavenly bodies? Describe their appearance and motion. Of what three parts may comets be considered to be composed? Describe these parts severally.

two opposite sides of the same hoop be extended, so that it shall be long. and narrow, it will then represent the orbit of a comet. The Sun is always in one of the foci of the comet's orbit.

There is, however, a practical difficulty of a peculiar nature which embarrasses the solution of the question as to the form of the cometary orbits. It so happens that the only part of the course of a comet which can ever be visible, is a portion throughout which the ellipse, the parabola, and hyperbola, so closely resemble each other, that no observations can be obtained with sufficient accuracy to enable us to distinguish them. In fact, the observed path of any comet, while visible, may belong either to an ellipse, parabola, or hyperbola.

That part which is usually *brighter*, or more *opaque*, than the other portions of the comet, is called the *nucleus.* This is surrounded by an *envelope*, which has a cloudy, or *hairy* appearance. These two parts constitute the body, and, in many instances, the whole of the comet.

Most of them, however, are attended by a long train, called the *tail;* though some are without this appendage, and as seen by the naked eye, are not easily distinguished from the planets. Others again, have no apparent nucleus, and seem to be only globular masses of vapor.

Nothing is known with certainty of the composition of these bodies. The envelope appears to be nothing more than vapor, becoming more luminous and transparent when approaching the Sun. As the comets pass between us and the fixed stars, their envelopes and tails are so thin, that stars of very small magnitudes may be seen through them. Some comets, having no nucleus, are transparent throughout their whole extent.

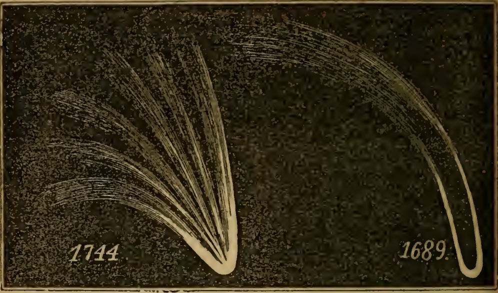
The nucleus of a comet sometimes appears opaque, and it then resembles a planet. Astronomers, however, are not agreed upon this point. Some affirm that the nucleus is always transparent, and that comets are in fact nothing but a mass of vapor, or less condensed at the center. By others it is maintained that the nucleus is sometimes solid and opaque. It seems probable, however, that there are three classes of comets; viz.: 1st, Those which have no nucleus, being transparent throughout their whole extent; 2d, Those which have a transparent nucleus; and, 3d, Those having a nucleus which is solid and opaque.

A comet, when at a distance from the Sun, viewed through a good telescope, has the appearance of a dense vapor surrounding the nucleus, and sometimes flowing far into the regions of space. As it approaches the Sun, its light becomes more brilliant, till it reaches its perihelion, when its

Have all comets these three parts? What apparent differences may be perceived in the composition of different comets? Into what classes, with reference to their composition, may comets be divided? Describe the different appearances of comets at different distances from the Sun. In what part of their orbit are their phenomena seen to the best advantage?

light is more dazzling than that of any other celestial body, the Sun excepted. In this part of its orbit are seen to the best advantage the phenomena of this wonderful body, which has, from remote antiquity, been the spectre of alarm and terror.

COMETS OF 1689 AND 1744.



The luminous train of a comet usually *follows it*, as it approaches the Sun, and *goes before it*, when the comet recedes from the Sun: sometimes the tail is considerably curved towards the region to which the comet is tending, and in some instances, it has been observed to form a right angle with a line drawn from the Sun through the center of the comet. The tail of the comet of 1744, formed nearly a quarter of a circle; that of 1689 was curved like a Turkish sabre. Sometimes the same comet has several tails. That of 1744 had, at one time, no less than *six*, which appeared and disappeared in a few days. The comet of 1823 had, for several days, two tails; one extending towards the Sun, and the other in the opposite direction.

Comets, in passing among and near the planets, are materially drawn aside from their courses, and in some cases have their orbits entirely changed. This is remarkably true in regard to Jupiter, which seems by some strange fatality to be constantly in their way, and to serve as a perpetual stumbling-block to them.

What is usually the direction of the luminous train? What was the direction of the tail of the comet of 1744? What was the direction of the tail of the comet of 1689? How many tails had the comet of 1744 at one time, and how long did they continue to appear? How many had that of 1823, and what was their direction? When comets pass near planets, how does the attraction of the planets affect them? In regard to what planet is this remarkably true? *Mention an example of comets being so affected.*

"The remarkable comet of 1770, which was found by Lexell to revolve in a moderate ellipse, in a period of about five years, actually *got entangled* among the satellites of Jupiter, and thrown out of its orbit by the attractions of that planet," and has not been heard of since.—*Herschel.* p. 310. By this extraordinary rencontre, the motions of Jupiter's satellites suffered not the least perceptible derangement; a sufficient proof of the aeriform nature of the comet's mass.

It is clear from observation, that comets contain very little *matter.* For they produce little or no effect on the motion of the planets when passing near those bodies; it is said that a comet, in 1454, eclipsed the moon; so that it must have been very near the Earth; yet no sensible effect was observed to be produced by this cause, upon the motion of the Earth or the Moon.

The observations of philosophers upon comets, have as yet detected nothing of their nature. Tycho Brahe and Appian, supposed their tails to be produced by the rays of the Sun transmitted through the nucleus, which they supposed to be transparent, and to operate as a lens. Kepler thought they were occasioned by the atmosphere of the comet, driven off by the impulse of the Sun's rays. This opinion, with some modification, was also maintained by Euler. Sir Isaac Newton conjectured, that they were a thin vapor, rising from the heated nucleus, as smoke ascends from the Earth; while Dr. Hamilton supposed them to be streams of electricity.

"That the luminous part of a comet," says Sir John Herschel, "is something in the nature of a smoke, fog, or cloud, suspended in a transparent atmosphere, is evident from a fact which has been often noticed, viz., that the portion of the tail where it comes up to, and surrounds the head, is yet separated from it by an interval less luminous; as we often see one layer of clouds laid over another with a considerable clear space between them." And again: "It follows that these can only be regarded as great masses of thin vapor, susceptible of being penetrated through their whole substance by the sunbeams."

Comets have always been considered by the ignorant and superstitious, as the harbingers of war, pestilence, and famine. Nor has this opinion been, even to this day, confined to the unlearned. It was once universal. And when we examine the dimensions and appearances of some of these bodies, we cease to wonder that they produced universal alarm.

According to the testimony of the early writers, a comet which could be seen in day-light with the naked eye, made its appearance 43 years before the birth of our Saviour. This date was just after the death of Cæsar, and by the Romans, the comet was believed to be his metamorphosed soul, armed with fire and vengeance. This comet is again mentioned as appearing in 1106, and then resembling the

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What fact connected with this case proves the aeriform nature of the comet's mass? How is it clear from observation that comets contain very little *matter?* What were the opinions of Tycho Brahe, Appian, Kepler, Euler, Sir Isaac Newton, and Dr. Hamilton, in regard to the tails of comets? *What was the opinion of Sir John Herschel, and on what founded?* How have comets been regarded by the ignorant and superstitious?

Sun in brightness, being of a great size, and having an immense tail.

In the year 1402, a comet was seen, so brilliant as to be discerned at noon-day.

In 1456, a large comet made its appearance. It spread a wider terror than was ever known before. The belief was very general, among all classes, that the comet would destroy the Earth, and that the Day of Judgment was at hand!

This comet appeared again in the years 1531, 1607, 1682, 1758, and 1835. It passed its perihelion in November, 1835, and will re-appear every 75½ years thereafter.

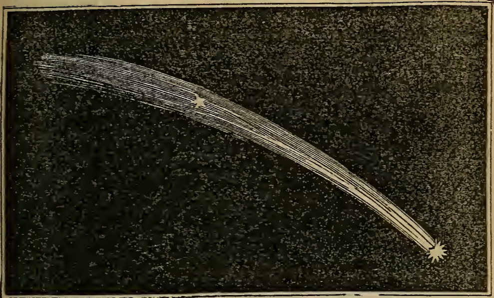
At the time of the appearance of this comet, the Turks extended their victorious arms across the Hellespont, and seemed destined to overrun all Europe. This added not a little to the general gloom. Under all these impressions, the people seemed totally regardless of the present, and anxious only for the future. The Romish Church held at this time unbounded sway over the lives, and fortunes, and consciences of men. To prepare the world for its expected doom, Pope Calixtus III. ordered the Ave Maria to be repeated three times a day, instead of two. He ordered the church bells to be rung at noon, which was the origin of that practice, so universal in Christian churches. To the Ave Maria, the prayer was added—"Lord, save us from the Devil, the Turk, and the Comet:" and once, each day, these three obnoxious personages suffered a regular excommunication.

The pope and clergy exhibiting such fear, it is not a matter of wonder that it became the ruling passion of the multitude. The churches and convents were crowded for confession of sins; and treasures uncounted were poured into the Apostolic chamber.

The comet, after suffering some months of daily cursing and excommunication, began to show signs of retreat, and soon disappeared from those eyes in which it found no favor. Joy and tranquillity soon returned to the faithful subjects of the pope, but not so their money and lands. The people, however, became satisfied that their lives, and the safety of the world, had been cheaply purchased. The pope, who had achieved so signal a victory over the monster of the sky, had checked the progress of the Turk, and kept, for the present, his Satanic majesty at a safe distance; while the Church of Rome, retaining her unbounded wealth, was enabled to continue that influence over her followers, which she retains, in part, to this day.

Mention some of the most remarkable comets which have appeared. Describe them severally, and relate in what manner they were severally regarded. *What is the periodic time of this comet?*

GREAT COMET OF 1680.



The comet of 1680 would have been still more alarming than that of 1456, had not science robbed it of its terrors, and history pointed to the signal failure of its predecessor. This comet was of the largest size, and had a tail whose enormous length was more than *ninety-six millions of miles.*

At its greatest distance, it is 13,000 millions of miles from the Sun; and at its nearest approach, only 574,000 miles from his center;* or about 130,000 miles from his surface. In that part of its orbit which is nearest the Sun, it flies with the amazing swiftness of 1,000,000 miles in an hour, and the Sun, as seen from it, appears 27,000 times larger than it appears to us; consequently, it is then exposed to a heat 27,000 times greater than the solar heat at the Earth. This intensity of heat exceeds, several thousand times, that of red-hot iron, and indeed all the degrees of heat that we are able to produce. A simple mass of vapor, exposed to a

* In Brewster's edition of Ferguson, this distance is stated as only 49,000 miles. This is evidently a mistake; for if the comet approached the Sun's center within 49,000 miles, it would penetrate 390,000 miles below the surface! Taking Ferguson's own elements for computing the perihelion distance, the result will be 494,460 miles. The mistake may be accounted for by supposing that the cipher had been omitted in the copy, and the period pointed off one figure farther to the left. Yet, with this alteration, it would still be incorrect; because the Earth's mean distance from the Sun, which is the integer of this calculation, is assumed at 82,000,000 of miles. The ratio of the comet's perihelion distance from the Sun, to the Earth's mean distance, as given by M. Pingré, is as 0.00603 to 1. This multiplied into 95,273,869, gives 574,500 miles for the comet's perihelion distance from the Sun's *center*: from which, if we subtract his semi-diameter, 443.840 miles, we shall have 130,660 miles, the distance of the comet from the surface of the Sun.

Again, if we divide the Earth's mean distance from the Sun, by the comet's perihelion distance, we shall find that the latter is only 1-166th part of the Earth's distance. Now the square of 166 is 27,556; and this expresses the number of times that the Sun appears *larger* to the comet, in the above situation, than it does to the Earth. Squire makes it 34,596 times larger.

According to Newton, the velocity is 880.000 miles per hour. More recent discoveries indicate a velocity of 1,240,108 miles per hour.

thousandth part of such a heat, would be at once dissipated in space—a pretty strong indication that, however volatile are the elements of which comets are composed, they are, nevertheless, capable of enduring an inconceivable intensity of both heat and cold.

This is the comet which, according to the reveries of Dr. Whiston and others, deluged the world in the time of Noah. Whiston was the friend and successor of Newton: but, anxious to know more than is revealed, he passed the bounds of sober philosophy, and presumed not only to fix the residence of the damned, but also the nature of their punishment. According to his theory, a comet was the awful prison-house in which, as it wheeled from the remotest regions of darkness and cold into the very vicinity of the Sun, hurrying its wretched tenants to the extremes of perishing cold and devouring fire, the Almighty was to dispense the severities of his justice.

Such theories may be ingenious, but they have no basis of facts to rest upon. They more properly belong to the chimeras of Astrology, than to the science of Astronomy.

When we are told by philosophers of great caution and high reputation, that the fiery train of the comet, just alluded to, extended from the horizon to the zenith; and that that of 1744 had, at one time, six tails, each 6,000,000 of miles long, and that another, which appeared soon after, had one 40,000,000 of miles long, and when we consider also the inconceivable velocity with which they speed their flight through the solar system, we may cease to wonder if, in the darker ages, they have been regarded as evil omens.

But these idle fantasies are not peculiar to any age or country. Even in our own times, the beautiful comet of 1811, the most splendid one of modern times, was generally considered among the superstitious, as the dread harbinger of the war which was declared in the following spring. It is well known that an indefinite apprehension of a more dreadful catastrophe lately pervaded both continents, in anticipation of Biela's comet of 1832.

The nucleus of the comet of 1811, according to observations made near Boston, was 2,617 miles in diameter, corresponding nearly to the size of the Moon. The brilliancy with which it shone, was equal to one tenth of that of the

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What is the degree of heat to which the comet of 1680 is exposed, when in its perihelion, compared to that experienced at the Earth? What is the intensity of such a degree of heat, compared with that of red-hot iron, or with any degree of heat which we are able to produce? What inference may be derived from this fact in regard to the composition of comets? What were the reveries of Dr. Whiston and others in regard to this comet? What facts ought to make us cease to wonder that comets were in darker ages considered as harbingers of evil? Have these fantasies, however, been confined to the darker ages? Of what event was the comet of 1811 considered, in our country, to be the harbinger?

Moon. The envelope, or aeriform covering, surrounding the nucleus, was 24,000 miles thick, about five hundred times as thick as the atmosphere which encircles the Earth; making the diameter of the comet, including its envelope, 50,617 miles. It had a very luminous tail, whose greatest length was *one hundred million of miles.*

COMETS OF 1811 AND 1819

This comet moved, in its perihelion, with an almost inconceivable velocity—fifteen hundred times greater than that of a ball bursting from the mouth of a cannon. According to Regiomontanus, the comet of 1472 moved over an arc of 120° in one day. Brydone observed a comet at Palermo in 1770, which passed through 50° of a great circle in the heavens in 24 hours. Another comet, which appeared in 1759, passed over 41° in the same time. The conjecture of Dr. Halley therefore seems highly probable, that if a body of such a size, having any considerable density, and moving with such a velocity, were to strike our Earth, it would instantly reduce it to chaos, mingling its elements in ruin.

The transient effect of a body passing near the Earth, could scarcely amount to any great convulsion, says Dr. Brewster; but if the Earth were actually to receive a shock from one of these bodies, the consequences would be awful. A new direction would be given to its rotary motion, and it would revolve around a new axis. The seas, forsaking their beds, would be hurried, by their centrifugal force, to the new equatorial regions: islands and continents, the abodes of men and animals, would be covered by the universal rush of the waters to the new equator, and every vestige of human industry and genius would be at once destroyed.

The chances against such an event, however, are so very numerous, that there is no reason to dread its occurrence.

Describe this comet. *Give some examples of the velocity of comets. What would probably be the effect upon the Earth, should a comet strike it? What does Dr. Brewster say would be the effect of a comet passing near the Earth? But if the Earth were actually to receive a shock from a comet, what does he say would be the results?*

The French government, not long since, called the attention of some of her ablest mathematicians and astronomers to the solution of this problem; that is, *to determine, upon mathematical principles, how many chances of collision the Earth was exposed to.* After a mature examination, they reported—"We have found that, of 281,000,000 of chances, there is only *one* unfavorable—there exists but *one* which can produce a collision between the two bodies."

"Admitting, then," say they, "for a moment, that the comets which may strike the Earth with their nucleuses, would annihilate the whole human race; the danger of death to each individual, resulting from the appearance of an *unknown comet*, would be exactly equal to the risk he would run, if in an urn there was only *one single* white ball among a total number of 281,000,000 balls, and that his condemnation to death would be the inevitable consequence of the white ball being produced at the first drawing."

We have before stated that comets, unlike the planets, observe no one direction in their orbits, but approach to, and recede from their great center of attraction, in every possible direction. Nothing can be more sublime, or better calculated to fill the mind with profound astonishment, than to contemplate the revolution of comets, while in that part of their orbits which comes within the sphere of the telescope. Some seem to come up from the immeasurable depths below the ecliptic, and, having doubled the heavens' mighty cape, again plunge downward with their fiery trains,

"On the long travel of a thousand years."

Others appear to come down from the zenith of the universe to double their perihelion about the Sun, and then reascend far above all human vision.

Others are dashing through the solar system in all possible directions, and apparently without any undisturbed or undisturbing path prescribed by Him who guides and sustains them all.

Until within a few years, it was universally believed that the periods of their revolutions must necessarily be of prodigious length; but within a few years, two comets have been discovered, whose revolutions are performed, comparatively, within our own neighborhood. To distinguish them from the more remote, they are denominated the *comets of a short period.* The first was discovered in the constellation Aquarius, by two French astronomers, in the year 1786. The same comet was again observed by Miss Caroline Herschel, in the constellation Cygnus, in 1795, and again in 1805. In 1818, Professor Encke determined the dimensions of its orbit,

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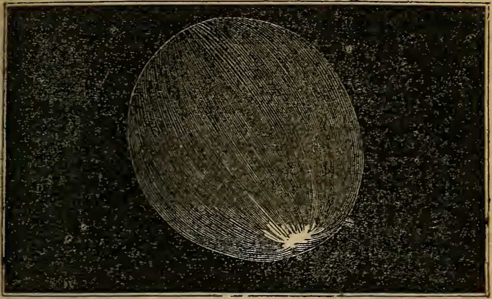
How did the French mathematicians and astronomers find the chances of a collision between the Earth and comets to stand? *What, on the supposition that a stroke of a comet would annihilate the whole human race, is the danger of death to each individual, resulting from the appearance of an unknown comet?*

What is the direction of comets in their orbits? What has been, until within a few years, the universal opinion in regard to the length of the times of their revolution? Why does not the same opinion prevail now? What are these two comets denominated?



and the period of its sidereal revolution; for which reason it has been called "*Encke's Comet.*"

This comet performs its revolution around the Sun in about 3 years and 4 months, in an elliptical orbit which lies wholly within the orbit of Jupiter. Its *mean* distance from the Sun is 212 millions of miles; the eccentricity of its orbit is 179 millions of miles; consequently, it is 358 millions of miles nearer the Sun in its perihelion, than it is in its aphelion. It was visible throughout the United States in 1825, when it presented a fine appearance. It was also observed at its next return in 1828; but its return to its perihelion, on the 6th of May, 1832, was invisible in the United States, on account of its great southern declination. It has returned at regular periods since that time.

The second "Comet of a short period," was observed in 1772; and was seen again in 1805. It was not until its re-appearance in 1826, that astronomers were able to determine the elements of its orbit, and the exact period of its revolution. This was successfully accomplished by M. Biela of Josephstadt; hence it is called *Biela's Comet.* According to observations made upon it in 1805, by the celebrated Dr. Olbers, its diameter, including its envelope, is 42,280 miles. It is a curious fact, that the path of Biela's comet passes very near to that of the Earth; so near, that at the moment

Relate the history of the discovery of the first. Why is it called Encke's comet? What is the time of the revolution of Encke's comet? What is the form of its orbit, and what its position with regard to the orbit of Jupiter? What is this comet's mean distance from the Sun? What is the eccentricity of its orbit?

How much nearer the Sun, then, is the comet, when in its perihelion than when in its aphelion? In what years has this comet been seen in the United States? Why was it not visible in the United States at the time of its return in 1832? Relate the history of the discovery of the second comet of a short period. Why is it called Biela's comet?

the center of the comet is at the point nearest to the Earth's path, the matter of the comet extends beyond that path, and includes a portion within it. Thus, if the Earth were at that point of its orbit which is nearest to the path of the comet, at the same moment that the comet should be at that point of its orbit which is nearest to the path of the Earth, the Earth would be enveloped in the nebulous atmosphere of the comet.

With respect to the effect which might be produced upon our atmosphere by such a circumstance, it is impossible to offer any thing but the most vague conjecture. Sir John Herschel was able to distinguish stars as minute as the 16th or 17th magnitude *through the body of the comet!* Hence it seems reasonable to infer, that the nebulous matter of which it is composed, must be infinitely more attenuated than our atmosphere; so that for every particle of cometary matter which we should inhale, we should inspire millions of particles of atmospheric air.

This is the comet which was to come into collision with the Earth, and to blot it out from the Solar System. In returning to its perihelion, November 26th, 1832, it was computed that it would cross the Earth's orbit at a distance of only 18,500 miles. It is evident that if the Earth had been in that part of her orbit at the *same time* with the comet, our atmosphere would have mingled with the atmosphere of the comet, and the two bodies, perhaps, have come in contact. But the comet passed the Earth's orbit on the 29th of October, in the 8th degree of Sagittarius, and the Earth did not arrive at that point until the 30th of November, which was 32 days afterwards.

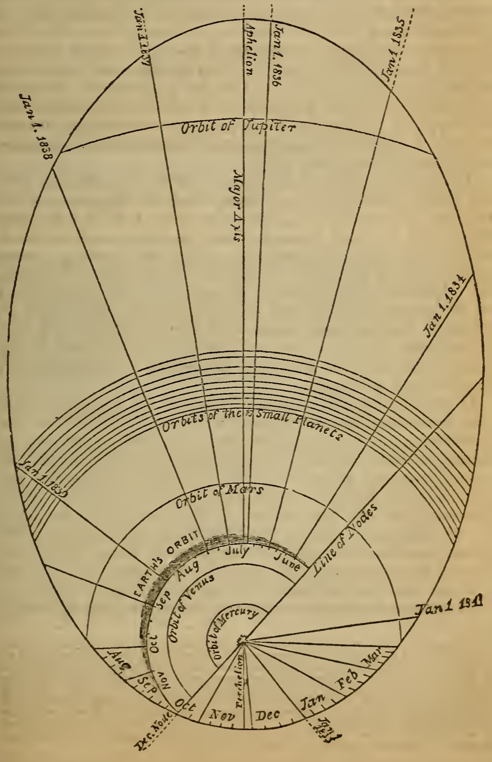
If we multiply the number of hours in 32 days, by 68,000 (the velocity of the Earth per hour), we shall find that the Earth was more than 52,000,000 miles behind the comet when it crossed her orbit. Its nearest approach to the Earth, at any time, was about 51 millions of miles; its nearest approach to the Sun, was about 83 millions of miles. Its mean distance from the Sun, or half the longest axis of its orbit, is 337 millions of miles. Its eccentricity is 253 millions of miles; consequently, it is 507 millions of miles nearer the Sun in its perihelion than it is in its aphelion. The period of its sidereal revolution is 2,460 days, or about 6¾ years.

The following representation of the entire orbit of Biela's

What, according to the observations of Dr. Olbers in 1805, was the diameter of Biela's comet, including the envelope? How near does the path of Biela's comet lie to that of the Earth? What would be the effect upon our atmosphere would the nebulous atmosphere of the comet envelope it? What reason have we to suppose that it is more attenuated than our atmosphere? It was predicted that this comet would come into collision with the Earth; what were the grounds of probability that such an event would take place, and why did it not? What was its nearest approach to the Earth at any time? What its nearest approach to the Sun? What its mean distance from the Sun? What its eccentricity? What, then, is the difference between its perihelion and aphelion distances? What is the period of its sidereal revolution?

comet, was obtained from the Astronomer Royal of the Greenwich Observatory. It shows not only the space and position it occupies in the solar system, but the points where its orbit intersects all the planetary orbits through which it passes. By this, it is seen that its perihelion lies between the orbits of the Earth and Venus, while its aphelion extends a little beyond that of Jupiter.

ORBIT OF BIELA'S COMET.



Although the comets of Encke and Biela are objects of very great interest, yet their short periods, the limited space within which their motion is circumscribed, and consequently the very slight disturbance which they sustain from the attraction of the planets, render them of less interest to physical astronomy than those of longer periods.

They do not, like them, rush from the invisible and inaccessible depths of space, and, after sweeping our system, depart to distances with the conception of which the imagination itself is confounded. They possess none of that grandeur which is connected with whatever appears to break through the fixed order of the universe. It is reserved for the comet of Halley alone to afford the proudest triumphs to those powers of calculation by which we are enabled to follow it in the depths of space, two thousand millions of miles beyond the extreme verge of the solar system; and, notwithstanding disturbances which render each succeeding period of its return different from the last, to foretell that return with precision.

To be able to predict the very day and circumstances of the return of such a bodiless and eccentric wanderer, after the lapse of so many years, evinces a perfection of the astronomical *calculus* that may justly challenge our admiration.

"The re-appearance of this comet," says Herschel, "whose return in 1832 was made the subject of elaborate calculations by mathematicians of the first eminence, did not disappoint the expectation of astronomers. It is hardly possible to imagine any thing more striking than the appearance, after the lapse of nearly seven years, of such an all but imperceptible cloud or wisp of vapor, *true, however, to its predicted time and place*, and obeying laws like those which regulate the planets."

Herschel, whose Observatory is at *Slough*, England, observed the daily progress of this comet from the 24th of September, until its disappearance, compared its *actual* position from day to day with its *calculated* position, and found them to agree within four or five minutes of time in right ascension, and within a *few seconds* of declination. Its position, then, as represented on a planisphere which the author prepared for his pupils, and afterwards published, was true to within a less space than one third of its projected diameter. Like some others that have been observed, this comet has no luminous train by which it can be easily recognized by the naked eye, except when it is very near the Sun. This is the reason why it was not more generally observed at its late return.

Although this comet is usually denominated "Biela's comet," yet it seems that M. Gambart, director of the Observatory at Marseilles, is equally entitled to the honor of identifying it with the comet of 1772, and of 1805. He discovered it only 10 days after Biela, and immediately set about calculating its elements from his own observations, which are thought to equal, if they do not surpass, in point of accuracy, those of every other astronomer.

Up to the beginning of the 17th century, no correct notions had been entertained in respect to the paths of comets. Kepler's first conjecture was that they moved in straight lines; but as that did not agree with observation, he next concluded that they were parabolic curves, having the Sun

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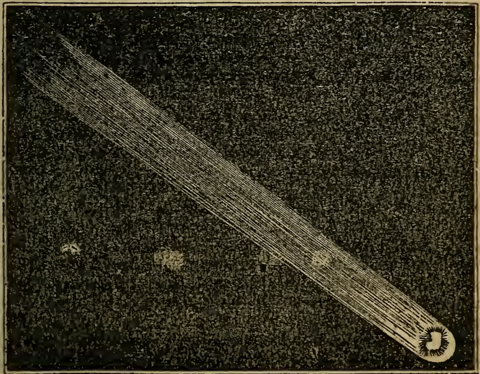
Why are the comets of Encke and Biela objects of less interest to physical astronomy than those of longer periods? What is the situation of the orbit of Biela's comet in the solar system? When will it return again? *How much did its actual position from day to day, as observed by Herschel, differ from its calculated position? Why was it not more generally observed at its late return? What astronomer besides Biela identified it with the comet of* 1772 *and* 1805? What were the opinions of astronomers in regard to the paths of comets, up to the beginning of the 17th century? What were Kepler's opinions on this subject?

near the vertex, and running indefinitely into the regions of space at both extremities. There was nothing in the observations of the earlier astronomers to fix their identity, or to lead him to suspect that any one of them had ever been seen before; much less that they formed a part of the solar system, revolving about the Sun in elliptical orbits that returned into themselves.

This grand discovery was reserved for one of the most industrious and sagacious astronomers that ever lived—this was Dr. Halley, the contemporary and friend of Newton. When the comet of 1682 made its appearance, he set himself about observing it with great care, and found there was a wonderful resemblance between it and three other comets that he found recorded, the comets of 1456, of 1531, and 1607. The times of their appearance had been nearly at equal and regular intervals; their perihelion distances were nearly the same; and he finally proved them to be one and the same comet, performing its circuit around the Sun in a period varying a little from 76 years. It is therefore called *Halley's* comet.

HALLEY'S COMET, 1682.



This is the very same comet that filled the eastern world with so much consternation in 1456, and became an object of such abhorrence to the church of Rome.

Who first discovered the identity of comets? Relate the manner by which he came to this discovery.

The periodic times of the three comets just described, are as follows:

Encke's, 1212 days.
Biela's, 2461 "
Halley's, 28,000 days.

Halley's comet, true to its predicted time and place, is now (Oct. 1835) visible in the evening sky. But we behold none of those phenomena which threw our ancestors of the middle ages into agonies of superstitious terror. We see not the *cometa horrendæ magnitudinis*, as it appeared in 1305, nor that tail of enormous length which, in 1456, extended over two thirds of the interval between the horizon and the zenith, nor even a star as brilliant as was the same comet in 1682, with its tail of 30°.

Its mean distance from the Sun is 1,713,700,000 miles; the eccentricity of its orbit is 1,658,000,000 miles; consequently it is 3,316,000,000 miles farther from the Sun in its aphelion than it is in its perihelion. In the latter case its distance from the Sun is only 55,700,000 miles; but in the former it is 3,371,700,000 miles. Therefore, though its aphelion distance be great, its mean distance is less than that of Herschel; and great as is the aphelion distance, it is but a very small fraction less than *one five thousandth* part of that distance from the Sun, beyond which the very nearest of the fixed stars must be situated; and, as the determination of their distance is negative and not positive, the nearest of them may be at twice or ten times that distance.

The number of comets which have been observed since the Christian era, amounts to 700. Scarcely a year has passed without the observation of one or two. And since multitudes of them must escape observation, by reason of their traversing that part of the heavens which is above the horizon in the day time, their whole number is probably many thousands. Comets so circumstanced, can only become visible by the rare coincidence of a total eclipse of the Sun—a coincidence which happened, as related by Seneca, 60 years before Christ, when a large comet was actually observed very near the Sun.

But M. Arago reasons in the following manner, with respect to the number of comets:—The number of ascertained comets, which, at their least distances, pass within the orbit of Mercury, is thirty. Assuming that the comets are uniformly distributed throughout the solar system, there will be 117,649 times as many comets included within the orbit of Herschel, as there are within the orbit of Mercury. But as there are 30 within the orbit of Mercury, there must be 3,529,470 within the orbit of Herschel!

Of 97 comets whose elements have been calculated by astronomers, 24 passed between the Sun and the orbit of Mercury; 33 between the orbits of Mercury and Venus; 21 between the orbits of Venus and the Earth; 15 between the orbits of Ceres and Jupiter. 49 of these comets move from east to west, and 49 in the opposite direction.

The total number of distinct comets, whose paths during the visible part of their course had been ascertained, up to the year 1832, was one hundred and thirty-seven.

What regions these bodies visit, when they pass beyond the limits of our view; upon what errands they come, when they again revisit the central parts of our system; what is the difference between their physical constitution and that of the Sun and planets; and what important ends they are destined to accomplish, in the economy of the universe, are

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In what time do the three comets just described accomplish their respective revolutions? *What comet was visible (Oct. 1835)? What are the mean, and the aphelion and perihelion distances of Halley's comet from the Sun? What part of the distance beyond which the nearest of the fixed stars must be placed, is its aphelion distance? What is the number of comets which have been observed since the Christian era? Why must some of them escape observation? How great is probably their actual number? In what case alone can comets which traverse the horizon in the day time become visible? Mention an instance of a comet thus becoming visible. What is the reasoning of M. Arago in regard to the number of comets? Describe the track among the orbits of the planets, of the 97 comets whose elements have been calculated by astronomers. In what direction do they move? What, up to the year 1832, was the whole number of distinct comets, whose path, during the visible part of their course, has been determined?*

inquiries which naturally arise in the mind, but which surpass the limited powers of the human understanding at present to determine.

CHAPTER XX.

OF THE FORCES BY WHICH THE PLANETS ARE RETAINED IN THEIR ORBITS.

Having described the real and apparent motions of the bodies which compose the solar system, it may be interesting next to show, that these motions, however varied or complex they may seem, all result from one simple principle, or law, namely, the

LAW OF UNIVERSAL GRAVITATION.

It is said, that Sir Isaac Newton, when he was drawing to a close the demonstration of the great truth, that gravity is the cause which keeps the heavenly bodies in their orbits, was so much agitated with the magnitude and importance of the discovery he was about to make, that he was unable to proceed, and desired a friend to finish what the intensity of his feelings did not allow him to do. By *gravitation* is meant, that universal law of attraction, by which every particle of matter in the system has a tendency to every other particle.

This attraction, or tendency of bodies towards each other, is in proportion to the quantity of matter they contain. The Earth, being immensely large in comparison with all other substances in its vicinity, destroys the effect of this attraction between smaller bodies, by bringing them all to itself.

The attraction of gravitation is reciprocal. All bodies not only attract other bodies, but are themselves attracted, and both according to their respective quantities of matter. The Sun, the largest body in our system, attracts the Earth and all the other planets, while they in turn attract the Sun. The Earth, also, attracts the Moon, and she in turn attracts the Earth. A ball, thrown upwards from the Earth, is brought again to its surface; the Earth's attraction not only counterbalancing that of the ball, but also producing a motion of the ball towards itself.

By what principle, or law, are the planets retained in their orbits? Who discovered this great truth, and how was he affected in view of it? What is meant by gravitation? To what is it proportioned? Give some example. How is it known tnat the attraction of gravitation is reciprocal? Give some examples to illustrate this principle.

This disposition, or tendency towards the Earth, is manifested in whatever falls, whether it be a pebble from the hand, an apple from a tree, or an avalanche from a mountain. All terrestrial bodies, not excepting the waters of the ocean, gravitate towards the center of the Earth, and it is by the same power that animals on all parts of the globe stand with their feet pointing to its center.

The power of terrestrial gravitation is greatest at the Earth's surface, whence it decreases both upwards and downwards; but not both ways in the same proportion. It decreases upwards *as the square of the distance* from the Earth's center increases; so that at a distance from the center equal to twice the semi-diameter of the Earth, the gravitating force would be only one fourth of what it is at the surface. But *below* the surface, it decreases in the *direct ratio* of the distance from the center; so that at a distance of half a semi-diameter from the center, the gravitating force is but half of what it is at the surface.

Weight and *Gravity*, in this case, are synonymous terms We say a piece of lead weighs a pound, or 16 ounces; but if by any means it could be raised 4000 miles above the surface of the Earth, which is about the distance of the surface from the center, and consequently equal to two semi-diameters of the Earth above its center, it would weigh only one fourth of a pound, or four ounces; and if the same weight could be raised to an elevation of 12,000 miles above the surface, or four semi-diameters above the center of the Earth, it would there weigh only one sixteenth of a pound, or one ounce.

The same body, at the center of the Earth, being equally attracted in every direction, would be without weight; at 1000 miles from the center it would weigh one fourth of a pound; at 2000 miles, one half of a pound; at 3000 miles, three fourths of a pound; and at 4000 miles, or at the surface, one pound.

It is a universal law of attraction, that *its power decreases as the square of the distance increases.* The converse of this is also true, viz.: *The power increases as the square of the distance decreases.* Giving to this law the form of a practical rule, it will stand thus:

The gravity of bodies above the surface of the Earth decreases in a duplicate ratio (or as the squares of their distances), in semi-diameters of the Earth, from the Earth's center. That is, when the gravity is *increasing. multiply* the weight by the square of the distance; but when the gravity is *decreasing, divide* the weight by the square of the distance.

Where is the power of terrestrial gravitation the greatest? From this point, does the power decrease *equally*, both upwards and downwards? What is the law of decrease *upwards?* Give an example. What is the law of decrease *downwards?* Give an example. What is the relation between weight and gravity? Illustrate it by some examples. *What, then, is the general law in regard to the increase and decrease of attraction? How may this law be expressed, in the form of a practical rule? Suppose, for example, the semi-diameter of the Earth be estimated, in round numbers, at 4000 miles, and that a body, elevated 2000 miles above its surface, should weigh 40 pounds.*

Suppose a body weighs 40 pounds at 2000 miles above the Earth's surface, what would it weigh at the surface, estimating the Earth's semi-diameter at 4000 miles? From the center to the given height, is $1\frac{1}{2}$ semi-diameters: the square of $1\frac{1}{2}$, or 1.5 is 2.25, which, multiplied into the weight, (40,) gives 90 pounds, the answer.

Suppose a body which weighs 256 pounds upon the surface of the Earth, be raised to the distance of the Moon (240,000 miles), what would be its weight? Thus, 4000)240,000(60 semi-diameters, the square of which is 3600. As the gravity in this case, is decreasing, *divide* the weight by the square of the distance, and it will give 3600)256(1-16th of a pound, or 1 ounce.

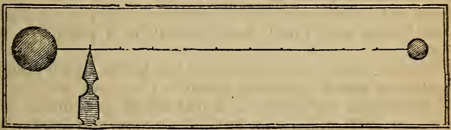
2. To find to what height a given weight must be raised to lose a certain portion of its weight.

RULE.—*Divide the weight at the surface, by the required weight, and extract the square root of the quotient.* Ex. A boy weighs 100 pounds, how high must he be carried to weigh but 4 pounds? Thus, 100 divided by 4, gives 25, the square root of which is 5 semi-diameters, or 20,000 miles above the center.

Bodies of equal magnitude do not always contain equal quantities of matter; a ball of cork, of equal bulk with one of lead, contains less matter, because it is more porous. The Sun, though *fourteen hundred thousand* times larger than the Earth, being much less dense, contains a quantity of matter only 355,000 times as great, and hence attracts the Earth with a force only 355,000 times greater than that with which the Earth attracts the Sun.

The quantity of matter in the Sun is 780 times greater than that of all the planets and satellites belonging to the Solar System; consequently their whole united force of attraction is 780 times less upon the Sun, than that of the Sun upon them.

CENTER OF GRAVITY.



The *Center of Gravity* of a body, is that point in which its whole weight is concentrated, and upon which it would rest, if freely suspended. If two weights, one of ten pounds, the other of one pound, be connected together by a rod eleven feet long, nicely poised on a center, and then be thrown into a free rotary motion, the heaviest will move in a circle with

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what would the same body weigh, if brought to the Earth's surface? Suppose a body which weighs 256 pounds upon the surface of the Earth, be raised to the distance of the Moon, what would be its weight at such an elevation? [The pupil should be required to give the calculation, as well as the answer.] *By what rule can we determine the height to which a body must be raised, in order to its losing a certain portion of its weight? Give an example.* Do bodies of the same magnitude always contain equal quantities of matter? What are the comparative bulks and densities of the Sun and Earth? How great is the quantity of matter in the Sun, compared with that of all the planets belonging to the solar system? What is the center of gravity of a body? Give an example.

a radius of one foot, and the lightest will describe a circle with a radius of ten feet: the center around which they move is their common center of gravity. *See the Figure.*

Thus the Sun and planets move around in an imaginary point as a center, always preserving an equilibrium.

If there were but one body in the universe, provided it were of uniform density, the center of it would be the center of gravity towards which all the surrounding portions would uniformly tend, and they would thereby balance each other. Thus the center of gravity, and the body itself, would forever remain at rest. It would neither move up nor down; there being no other body to draw it in any direction. In this case, the terms *up* and *down* would have no meaning, except as applied to the body itself, to express the direction of the surface from the center.

Were the Earth the only body revolving about the Sun, as the Sun's quantity of matter is 355,000 times as great as that of the Earth, the Sun would revolve in a circle equal only to the *three hundred and fifty-five thousandth* part of the Earth's distance from it: but as the planets in their several orbits vary their positions, the center of gravity is not always at the same distance from the Sun.

The quantity of matter in the Sun so far exceeds that of all the planets together, that were they all on one side of him, he would never be more than his own diameter from the common center of gravity; the Sun is therefore justly considered as the center of the system.

The quantity of matter in the Earth being about 80 times as great as that of the Moon, their common center of gravity is 80 times nearer the former than the latter, which is about 3000 miles from the Earth's center.

The secondary planets are governed by the same laws as their primaries, and both together move around a common center of gravity.

Every system in the universe is supposed to revolve in like manner, around *one common center.*

How does this illustration apply to planetary motion? If there were but one single body in the universe, where would the center of gravity be? What motion would the body have? What would the terms *up* and *down*, in such case, mean? If the Earth were the only body revolving about the Sun, what would be their relative distances from their common center of gravity? If, instead of the Earth alone, the Earth with all the planets and satellites of the system were on one side, and the Sun alone on the other, at what distance from their common center of gravity must the Sun be, to balance them all? Where is the center of gravity between the Earth and the Moon? How do you know this? By what laws are the secondary planets governed, and the other systems of the universe?

ATTRACTIVE AND PROJECTILE FORCES.

All simple motion is naturally rectilinear; that is, all bodies put in motion would continue to go forward in straight lines, as long as they met with no resistance or diverting force.

On the other hand, the Sun, from his immense size, would, by the power of attraction, draw all the planets to him, if his attractive force were not counterbalanced by the primitive impulse of the planetary bodies to move in straight lines.

The attractive power of a body drawing another body towards the center, is denominated *Centripetal force;* and the tendency of a revolving body to fly *from* the center in a tangent line, is called the *Projectile* or *Centrifugal force.* The joint action of these two central *forces* gives the planets a circular motion, and retains them in their orbits as they revolve, the primaries about the Sun, and the secondaries about their primaries.

The *degree* of the Sun's attractive power at each particular planet, whatever be its distance, is uniformly equal to the centrifugal force of the planet. The nearer any planet is to the Sun, the more strongly is it attracted by him; the farther any planet is from the Sun, the less is it attracted by him; therefore, those planets which are the nearer to the Sun, must move the faster in their orbits, in order thereby to acquire centrifugal forces equal to the power of the Sun's attraction; and those which are the farther from the Sun, must move the slower, in order that they may not have too great a degree of centrifugal force, for the weaker attraction of the Sun at those distances.

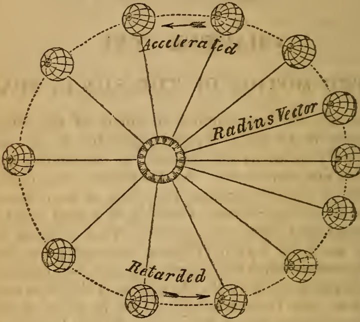
The discovery of these great truths, by Kepler and Newton, established the UNIVERSAL LAW OF PLANETARY MOTION; which may be stated as follows:

1. Every planet moves in its orbit with a velocity varying every instant, in consequence of two forces; one tending to the center of the Sun, and the other in the direction of a tangent to its orbit, arising from the primitive impulse given at the time it was launched into space. The former is called its *Centripetal*, the latter, its *Centrifugal force.* Should the centrifugal force cease, the planet would fall to the Sun by its gravity; were the Sun not to attract it, it would fly off from its orbit in a straight line.

What is meant by all simple motion being rectilinear? Why does not the Sun, by its great attraction bring all bodies to its surface? Explain what is meant by centripetal and centrifugal forces. What results from the joint action of these two forces? To what is the Sun's attractive power at each particular planet equal? Explain this more fully. By whom was the universal law of planetary motion established? Repeat the law.

2. By the time a planet has reached its aphelion, or that point of its orbit which is farthest from the Sun, his attraction has overcome its velocity, and draws it towards him with such an accelerated motion, that it at last overcomes the Sun's attraction, and shoots past him; then gradually decreasing in velocity, it arrives at the perihelion, when the Sun's attraction again prevails.

MOTION OF THE PLANETS.



3. However ponderous or light, large or small, near or remote, the planets may be, their motion is always such that the *radius vector*, or line joining its center to the center of the Sun, passes over equal areas in equal times: and this is true not only with respect to the areas described every hour by the *same* planet, but the agreement holds, with rigid exactness, between the areas described in the same time, by *all* the planets and comets belonging to the Solar System.

From the foregoing principles, it follows, that the force of gravity, and the centrifugal force, are mutual *opposing powers*—each continually acting against the other. Thus, the weight of bodies on the Earth's equator, is *diminished* by the centrifugal force of her diurnal rotation, in the proportion of one pound for every 290 pounds: that is, had the Earth no motion on her axis, all bodies on the equator would weigh one *two hundred and eighty-ninth part* more than they now do.

On the contrary, if her diurnal motion were accelerated, the centrifugal force would be proportionally increased, and the weight of bodies at the equator would be, in the same ratio, diminished. Should the Earth revolve upon its axis with a velocity which would make the day but 84 minutes long, instead of 24 hours, the centrifugal force would counterbalance that of gravity, and all bodies at the equator would then be absolutely destitute of weight; and if the

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How is the weight of bodies on the Earth's equator affected by its diurnal rotation? What would be the effect if the diurnal motion of the Earth were accelerated? What would be the consequence if the Earth revolved about its axis in 84 minutes, or in less time?

centrifugal force were further augmented (the Earth revolving in less than 81 minutes), gravitation would be completely overpowered, and all fluids and loose substances near the equator would fly off from the surface.

The weight of bodies, either upon the Earth, or on any other planet having a motion around its axis, depends jointly upon the mass of the planet, and its diurnal velocity. A body weighing one pound upon the equator of the Earth, would weigh, if removed to the equator of the Sun, 27.9lbs.; of Mercury, 1.03 lbs.: of Venus, 0.98 lbs.; of the Moon, 1-6th of a lb.; of Mars, ½ lb.; of Jupiter, 2.716 lbs.; of Saturn, 1.01 lbs.

CHAPTER XXI.

PROPER MOTION OF THE SUN IN SPACE.

Though we are accustomed to speak of the Sun as the *fixed* center of the Solar System, the idea of his fixedness is correct only so far as his relation to the bodies revolving around him are concerned. As the planets accompanied by their satellites revolve around the Sun, so he is found to be moving, with all his retinue of worlds, in a *vast orbit*, around some distant and unknown center. This opinion was first advanced, we think, by Sir William Herschel; but the honor of actually determining this interesting fact, belongs to Struve, who ascertained not only the *direction* of the Sun and Solar System, but also their *velocity*. The point of tendency is towards the constellation Hercules, Right Ascension 259°, Declination 35°. The *velocity* of the Sun, &c., in space, is estimated at about 28,000 miles per hour, or nearly 8 miles per second!

With this wonderful fact in view, we may no longer consider the Sun as fixed and stationary, but rather as a vast and luminous *planet*, sustaining the same relation to some central orb, that the primary planets sustain to him, or that the secondaries sustain to their primaries. Nor is it necessary that the stupendous mechanism of nature should be restricted even to these sublime proportions. The Sun's central body may also have its orbit, and its center of attraction and motion, and so on, till, as Dr. Dick observes, we come to the great center of all—to the Throne of God.

Since the preceding was written, an article has appeared in several European journals, announcing the probable discovery of the Sun's *central orb ;* the *inclination of his orbit to the plane of the ecliptic ;* and his *periodic time !*

As it contains several interesting calculations and conclusions, it is here copied for the benefit of the student.

Is the Sun, strictly speaking, a *fixed* body? In what sense is he fixed? What proper motion has he? Towards what point is he tending? What is his velocity? What analogy, then, between the Sun and planets?

THE CENTRAL SUN.

At the close of the meeting of the Royal Irish Academy on the 14th of December, [1846,] Sir William Hamilton announced that he had just received from Professor Mädler, of Dorpat, the extraordinary and exciting intelligence of the presumed discovery of a central sun!

By an extensive and laborious comparison of the quantities and directions of the proper motions of the stars in various parts of the heavens, combined with indications afforded by the parallaxes hitherto determined, and with the theory of universal gravitation, Professor Mädler has arrived at the conclusion that the Pleiades form the central group of our whole astral or sidereal system, including the Milky Way and all the brighter stars, but exclusive of the more distant nebulæ, and of the stars of which those nebulæ may be composed. And within this central group itself he has been led to fix on the star Alcyone, (otherwise known by the name of η Tauri,) as occupying exactly or nearly the position of the center of gravity, and as entitled to be called the central sun.

Assuming Bessel's parallax of the star 61 Cygni, long since remarkable for its large proper motion, to be correctly determined, Mädler proceeds to form a first approximate estimate of the distance of this central body from the planetary or solar system; and arrives at the (provisional) conclusion, that Alcyone is about thirty-four million times as far removed from us, or from our own sun, as the latter luminary is from us. It would, therefore, according to this estimation, be at least a million times as distant as the new planet, of which the theoretical or deductive discovery has been so great and beautiful a triumph of modern astronomy, and so striking a confirmation of the law of Newton. The same approximate determination of distance conducts to the result, that the light of the central sun occupies more than five centuries in traveling thence to us.

The enormous orbit which our own sun, with the earth and the other planets, is thus inferred to be describing about that distant center—not indeed under its influence alone, but by the combined attractions of all the stars which are nearer to it than we are, and which are estimated to amount to more than one hundred and seventeen millions of masses, each equal to the total mass of our own Solar System—is

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Where does Mädler locate "The Central Sun?" What star of the group does he designate as the probable center? How distant does he suppose it to be, as compared with Leverrier? How long would it require for light to traverse this space? What is the supposed period of the Sun's revolution? What the inclination of his orbit to the plane of the ecliptic?

supposed to require upwards of *eighteen millions of years* for its complete description, at the rate of about eight geographical miles in every second of time.

The plane of this vast orbit of the sun is judged to have an inclination of about eighty-four degrees to the ecliptic, or to the plane of the annual orbit of the earth; and the longitude of the ascending node of the former orbit on the latter is concluded to be nearly two hundred and thirty-seven degrees.

CHAPTER XXII.

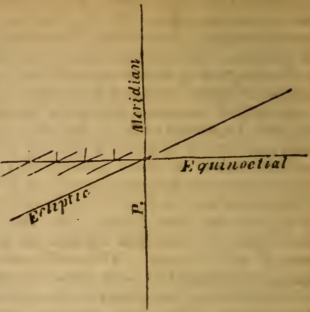
PRECESSION OF THE EQUINOXES—OBLIQUITY OF THE ECLIPTIC.

Of all the motions which are going forward in the Solar System, there is none, which it is important to notice, more difficult to comprehend, or to explain, than what is called the PRECESSION OF THE EQUINOXES.

The equinoxes, as we have learned, are the two opposite points in the Earth's orbit, where it crosses the equator. The first is in Aries; the other, in Libra. By the *precession* of the equinoxes is meant, that the intersection of the equator with the ecliptic is not always in the same point:—in other words, that the Sun, in its apparent annual course, does not cross the equinoctial, Spring and Autumn, exactly in the same points, but every year a little *behind* those of the preceding year.

This annual falling back of the equinoctial points, is called by astronomers, with reference to the motion of the heavens, the *Precession of the Equinoxes;* but it would better accord with fact as well as the apprehension of the learner, to call it, as it is, the *Recession* of the Equinoxes: for the equinoctial points do actually *recede* upon the ecliptic, at the rate of about 50¼″ of a degree every year. It is the name only, and not the position, of the equinoxes which remains permanent. *Wherever* the Sun crosses the equinoctial in the *spring*, *there* is the vernal equinox; and *wherever* he crosses it in the *autumn*, *there* is the autumnal equinox, and these points are constantly moving to the west.

What are the equinoxes? What is meant by the *precession* of the equinoxes? Why is it called *precession* of the equinoxes, and what would be a better term? The equinoctial points are continually moving; how then is their position defined?



To render this subject familiar, we will suppose two carriage roads, extending quite around the Earth: one, representing the equator, running due east and west; and the other representing the ecliptic, running nearly in the same direction as the former, yet so as to cross it with a small angle (say of 23½°), both at the point where we now stand, for instance, and in the nadir, exactly opposite; let there also be another road, to represent the prime meridian, running north and south, and crossing the first at right angles, in the common point of intersection, as in the annexed figure.

Let a carriage now start from this point of intersection, not in the road leading directly east, but along that of the ecliptic, which leaves the former a little to the north, and let a person be placed to watch when the carriage comes around again, after having made the circuit of the Earth, and see whether the carriage will cross the equinoctial road again precisely in the *same track* as when it left the goal. Though the person stood exactly in the former track, he need not fear being run over, for the carriage will cross the road 100 rods west of him, that is, 100 rods west of the meridian on which he stood It is to be observed, that 100 rods on the equator is equal to 50¼ seconds of a degree.

If the carriage still continue to go around the Earth, it will, on completing its second circuit, cross the equinoctial path 200 rods west of the meridian whence it first set out; on the third circuit, 300 rods west; on the fourth circuit, 400 rods, and so on, continually. After 71⅔ circuits, the point of intersection would be one degree west of its place at the commencement of the route. At this rate it would be easy to determine how many complete circuits the carriage must perform before this continual falling back of the intersecting point would have retreated over every degree of the orbit, until it reached again the point from whence it first departed. The application of this illustration will be manifest, when we consider, further, that

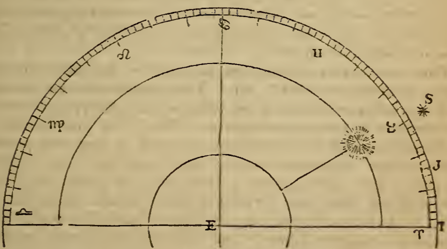
The Sun revolves from one equinox to the same equinox again, in 365d. 5h. 48′ 47″ .81. This constitutes the natural, or *tropical year*, because, in this period, one revolution of the seasons is exactly completed. But it is, meanwhile, to be borne in mind, that the equinox itself, during this period, has not kept its position among the stars, but has deserted its place, and *fallen back* a little way to meet the Sun; whereby the Sun has arrived at the equinox *before* he has arrived at the same position among the stars from which he departed the year before; and consequently, must perform as *much more* than barely a *tropical* revolution, to reach that point again.

Give at length a familiar illustration by which this subject may be understood. Suppose the carriage continues its circuit around the Earth, where would it cross the equinoctial the 2d, 3d, and 4th times, &c.? After how many circuits would this falling back of the equinoctial points amount to one degree on the ecliptic? In what time does the Sun revolve from one equinox to the same equinox again? What is this period called? Why is it so called? Does the equinox remain stationary [during] this period? What results from this?

To pass over this interval, which *completes the Sun's sidereal revolution*, takes (20′ 22″.94) about 22 minutes and 23 seconds longer. By adding 22 minutes and 23 seconds to the time of a tropical revolution, we obtain 365d. 6h. 9m.10¾s. for the length of a *sidereal revolution;* or the time in which the Sun revolves from one fixed star to the same star again.

As the Sun describes the whole ecliptic, or 360°, in a tropical year, he moves over 59′ 8⅓″ of a degree every day, at a mean rate, which is equal to 50¼″ of a degree in 20 minutes and 23 seconds of time; consequently he will arrive at the same equinox or solstice when he is 50¼″ of a degree *short of the same star* or fixed point in the heavens, from which he set out the year before. So that, with respect to the fixed stars, the Sun and equinoctial points fall back, as it were, 1° in 71⅔ years. This will make the stars *appear to have gone forward* 1°, with respect to the *signs* in the ecliptic, in that time: for it must be observed, that *the same signs always keep in the same points of the ecliptic, without regard to the place of the constellations.* Hence it becomes necessary to have new plates engraved for celestial globes and maps, at least once in 50 years, in order to exhibit truly the altered position of the stars. At the present rate of motion, the *recession* of the equinoxes, as it should be called, or the *precession* of the stars, amounts to 30°, or one whole sign, in 2140 years.

MOTION OF THE STARS.



To explain this by a figure: Suppose the Sun to have been in conjunction with a fixed star at S, in the first degree of Taurus, (the second sign of the ecliptic,) 340 years before the birth of our Saviour, or about the 17th year of Alexander the Great: then having made 2140 revolutions through the ecliptic, he would be found again at the end of so many *sidereal years* at S: but at the end of so many ***Julian years***, he would be found at J, and at the end of so many *tropical years*, which would bring it down to the beginning of the present century, he would be found at T, in the first degree of Aries, which has receded from S to T in that time by the precession of the equinoctial points Aries and Libra. The arc S T would be equal to the amount of the precession (for *precession* we must still call it) of the equinox in 2140 years, at the rate of 50″.23572 of a degree, or 20 minutes and 23 seconds of time annually, as above stated.

From the constant retrogradation of the equinoctial points, and with them of all the signs of the ecliptic, it follows that *the longitude of the stars must continually increase.* The same cause affects also their *right ascension and declination.* Hence, those stars which, in the infancy of astronomy were in the sign *Aries*, we now find in *Taurus;* and those which were in *Taurus*, we now find in *Gemini*, and so on. Hence likewise it is, that the star which rose or set at any particular time of the year, in the time of Hesiod, Eudoxus, Virgil, Pliny, and others, by no means answers at this time to their descriptions.

Hesiod, in his *Opera et Dies*, lib. ii. verse 185, says:

When from the solstice sixty wintry days
Their turns have finished, mark, with glitt'ring rays,
From Ocean's sacred flood, Arcturus rise,
Then first to gild the dusky evening skies.

But Arcturus *now* rises acronycally in latitude 37° 45′ N. the latitude of Hesiod, and nearly that of Richmond, in Virginia, about 100 days after the winter solstice. Supposing Hesiod to be correct, there is a difference of 40 days arising from the precession of the equinoxes since the days of Hesiod. Now as there is no record extant of the exact period of the world when this poet flourished, let us see to what result astronomy will lead us.

As the Sun moves through about 39° of the ecliptic in 40 days, the winter solstice, in the time of Hesiod, was in the 9th degree of Aquarius. Now estimating the precession of the equinoxes at $50\frac{1}{4}''$ in a year, we shall have $50\frac{1}{4}''$: 1 year : : 39° : 2794 years since the time of Hesiod: if we substract from this our present era, 1836, it will give 958 years before Christ. Lempriere, in his Classical Dictionary, says Hesiod lived 907 years before Christ. See a similar calculation for the time of Thales, page 54.

The retrograde movement of the equinoxes, and the annual extent of it, were determined by comparing the longitude of the same stars, at different intervals of time. The most careful and unwearied attention was requisite in order to determine the cause and extent of this motion; a motion so very slow as scarcely to be perceived in an age, and occupying not less than 25,000 years in a single revolution. It has not yet completed *one quarter of its first circuit* in the heavens since the creation.

Thus observation has not only determined the absolute

How long does it take the Sun to pass over the interval of space through which the equinox has thus retreated? What is the length of a sidereal revolution, and how is it determined? What portion of the ecliptic does the Sun describe, at a mean rate, every day What portion does it describe in 20 minutes and 23 seconds? If the Sun and equinoctial points fall back in the ecliptic 50 1-4″ of a degree every year, how many years before this regression will amount to a degree? How will this affect the appearance of the stars? What practical inconvenience results from this fact? In what period of time does the precession of the stars amount to 30°, or one whole sign? *Explain this by a diagram.* How does the retrogradation of the equinoctial points affect the *longitude* of the stars? Does the same cause extend to the right ascension and declination also? How is this rendered apparent? *Mention an example. History does not enable us to fix the precise age of the world in which Hesiod flourished; what light does astronomy shed upon this question?* By what means was the retrogradation of the equinoxes determined? Why was it difficult to determine the cause and extent of this motion? Not to specify particular cases, what has observation at length determined, with respect to the *limit* and *uniformity* of this backward movement of the equinoctial points?

motion of the equinoctial points, but measured its limit; it has also shown that this motion, like the causes which produce it, is not uniform in itself: but that it is constantly accelerated by a slow arithmetical increase of 1″ of a degree in 4,100 years. A quantity which, though totally inappreciable for short periods of time, becomes sensible after a lapse of ages. For example: The retrogradation of the equinoctial points is now greater by nearly ½″ than it was in the time of *Hipparchus*, the first who observed this motion; consequently, the mean tropical year is *shorter* now by about 12 seconds than it was then. For, since the retrogradation of the equinoxes is now every year greater than it was then, the Sun has, each year, a space of nearly ½″ *less to pass through* in the ecliptic, in order to reach the plane of the equator. Now the Sun is 12 seconds of *time* in passing over ½″ of *space*.

At present, the equinoctial points move *backwards*, or *from east to west* along the path of the ecliptic at the rate of 1° in 71⅔ years, or one whole sign, in 2140 years. Continuing at this rate, they will fall back through the whole of the 12 signs of the ecliptic in 25,680 years, and thus return to the *same position among the stars*, as in the beginning.

But in determining the period of a complete revolution of the equinoctial points, it must be borne in mind that the motion itself is *continually increasing;* so that the last quarter of the revolution is accomplished several hundred years sooner than the first quarter. Making due allowance for this accelerated progress, the revolution of the equinoxes is completed in 25,000 years; or, more exactly, in 24,992 years.

Were the motion of the equinoctial points uniform; that is, did they pass through equal portions of the ecliptic in equal times, they would accomplish their first quarter, or pass through the *first three signs* of the ecliptic, in 6,250 years. But they are 6,575 years in passing through the first quarter; about 218 years *less* in passing through the second quarter; 218 less in passing through the third, and so on.

The immediate consequence of the precession of the equinoxes, as we have already observed, is a *continually progressive increase of longitude* in all the heavenly bodies. For the vernal equinox being the initial point of longitude,

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Give an example. Why should the tropical year, on this account, be shorter now than it was then? What is the present rate of motion of the equinoctial points? In what time, continuing at the same rate, will they fall back through the twelve signs of the ecliptic? In determining the exact period of a complete revolution of the equinoctial points, what important circumstance must be borne in mind? Making due allowance for their accelerated progress, in what time is a revolution of the equinoxes completed? Is this motion as quick in the first quarter of their revolution as in the last? What is the *time* and *difference* of describing each quarter? What is the immediate consequence of the precession of the equinoxes upon the position of the heavenly bodies? Explain how this takes place. How does this resemble the annual loss of a sidereal day by the Sun? What is the cause of this motion?

as well as of right ascension, a retreat of this point on the ecliptic, tells upon the longitudes of all alike, whether at rest or in motion, and produces, so far as its amount extends, the *appearance* of a motion in longitude common to them all, *as if* the whole heavens had a slow rotation around the poles of the ecliptic in the long period above mentioned, similar to what they have in every twenty-four hours around the poles of the equinoctial. As the Sun *loses* one day in the year on the stars, by his *direct* motion in longitude; so the equinox *gains* one day on them, in 25,000 years, by its *retrograde* motion.

The cause of this motion was unknown, until Newton proved that it was a necessary consequence of the rotation of the Earth, combined with its elliptical figure, and the unequal attraction of the Sun and Moon on its polar and equatorial regions. There being more matter about the Earth's equator than at the poles, the former is more strongly attracted than the latter, which causes a slight gyratory or wabbling motion of the poles of the Earth around those of the ecliptic, like the pin of a top about its center of motion, when it spins a little obliquely to the base.

The precession of the equinoxes, thus explained, consists in a real motion of the pole of the heavens among the stars, in a small circle around the pole of the ecliptic as a center, keeping constantly at its present distance of nearly 23½° from it, in a direction from east to west, and with a progress so very slow, as to require 25,000 years to complete the circle. During this revolution, it is evident that the pole will point successively to every part of the small circle in the heavens which it thus describes. Now this can not happen without producing corresponding changes in the apparent diurnal motion of the sphere, and in the aspect which the heavens must present at remote periods of time.

The effect of such a motion on the aspect of the heavens, is seen in the *apparent* approach of some stars and constellations to the celestial pole, and the recession of others. The bright star of the Lesser Bear, which we call the *pole star*, has not always been, nor will always continue to be, our polar star. At the time of the construction of the earliest catalogues, this star was 12° from the pole; it is now only 1° 34′ from it, and it will approach to within half a degree of it; after which it will again recede, and slowly give place to others, which will succeed it in its proximity to the pole.

Admitting this explanation, in what does the precession of the equinoxes really consist? To what point in the heavens will the pole of the Earth be directed, during the revolution? How must this affect the diurnal motion and aspect of the heavens, in remote ages? Wherein will the effects of such a motion be particularly visible? Give an instance.

The *pole*, as above considered, is to be understood, merely, as the *vanishing point* of the Earth's axis; or that point in the concave sphere which is *always opposite* the terrestrial pole, and which consequently must move as that moves.

The precession of the stars in respect to the equinoxes, is less apparent the greater their distance from the ecliptic; for whereas a star in the *zodiac* will appear to sweep the whole circumference of the heavens in an equinoctial year, a star situated within the *polar circle* will describe only a very small circle in that period, and by so much the less, as it approaches the pole. The north pole of the earth being elevated 23° 27½′ towards the tropic of Cancer, the circumpolar stars will be successively at the least distance from it, when their longitude is 3 signs, or 90° The position of the north polar star in 1836, was in the 17° of *Taurus;* when it arrives at the first degree of Cancer, which it will do in about 250 years, it will be at its nearest possible approach to the pole—namely, 29′ 55″. About 2900 years before the commencement of the Christian era, *Alpha Draconis*, the third star in the Dragon's tail, was in the first degree of Cancer, and only 10′ from the pole; consequently it was then the *pole star*. After the lapse of 11,600 years, the star *Lyra*, the brightest in the northern hemisphere, will occupy the position of a pole star, being then about 5 degrees from the pole; whereas *now* its north polar distance is upwards of 51°.

The mean average precession from the creation (4004 B. C.) to the year 1800, is 49″.51455; consequently the equinoctial points have receded since the creation, 2 s. 14° 8′ 27″. The longitude of the star *Beta Arietis*, was, in 1820, 31° 27′ 28″: *Meton*, a famous mathematician of Athens, who flourished 430 years before Christ, says, this star, in his time, was in the vernal equinox. If he is correct, then 31° 27′ 28″, divided by 2250 years, the elapsed time, will give 50⅓″ for the precession. Something, however, must be allowed for the imperfection of the instruments used at that day, and even until the sixteenth century.

Since all the stars complete half a revolution about the axis of the ecliptic in about 12,500 years, if the *North Star* be at its nearest approach to the pole 250 years hence, it will, 12,500 years afterwards, be at its greatest possible distance from it, or about 47° above it:—That is, the star itself will remain immovable in its present position, but the pole of the Earth will *then* point as much *below* the pole of the ecliptic, as *now* it points above. This will have the effect,

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When you speak of the POLE *as in motion, what is to be understood by that term?* Is the precession of the stars, with respect to the equinoxes, equally apparent in every part of the heavens? At what longitude do the circumpolar stars approach nearest the pole? What is the position, at present, of the north polar star, and when will it make its nearest possible approach to the true pole of the heavens? At what period has any other star been the polar star? When will the star *Lyra*, which is more than 50° from it, be the north polar star? *What was the mean annual precession from the creation to the year* 1800, *and how much did it amount to in that period? When was Beta Arietis in the equinox, and what is its longitude now?* When will our present north star be at its least, and when at its greatest distance from the pole? In this case, is it meant that the star itself will move, or the pole? In what manner? What, then, must be the apparent effect?

apparently, of elevating the present polar star to twice its present altitude, or 47°. Wherefore, at the expiration of half the equinoctial year, that point of the heavens which is now 1° 18′ north of the zenith of Hartford, will be the place of the north pole, and all those places which are situated 1° 18′ north of Hartford, will then have the present pole of the heavens in their zenith.

OBLIQUITY OF THE ECLIPTIC.

The distance between the equinoctial and either tropic, measured on the meridian, is called the *Obliquity of the Ecliptic:* or, this obliquity may be defined as the angle formed by the intersection of the celestial equator with the ecliptic. Hitherto, we have considered these great primary circles in the heavens, as never varying their position in space, nor with respect to each other. But it is a remarkable and well-ascertained fact, that both are in a state of constant change. We have seen that the plane of the Earth's equator is constantly drawn out of place by the unequal attraction of the Sun and Moon acting in different directions upon the unequal masses of matter at the equator and the poles; whereby the intersection of the equator with the ecliptic is constantly retrograding—thus producing the *precession of the equinoxes.*

The displacement of the *ecliptic*, on the contrary, is produced chiefly by the action of the planets, particularly of Jupiter and Venus, on the Earth; by virtue of which the plane of the Earth's orbit is drawn nearer to those of these two planets, and consequently, nearer to the plane of the equinoctial. The tendency of this attraction of the planets, therefore, is to *diminish the angle* which the plane of the equator makes with that of the ecliptic, bringing the two planes nearer together; and if the Earth had no motion of rotation, it would, in time, cause the two planes to coincide. But in consequence of the rotary motion of the Earth, the inclination of these planes to each other remains very nearly the same; its annual diminution being scarcely more than *three fourths of one second of a degree in a year.*

The obliquity of the ecliptic, at the commencement of the present century, was, according to *Baily*, 23° 27′ 56½″, subject to a yearly diminution of 0″ .4755. According to *Bessel*, it was 23° 27′ 54″ .32, with an annual diminution of 0″ .46.

Illustrate these phenomena by a diagram. What is the obliquity of the ecliptic? In what light have we hitherto considered the great circles of the heavens? But what is the fact? By what cause is the displacement of the equinoctial, or the plane of the Earth's equator, effected? How is the displacement of the plane of the ecliptic effected? If the planetary attraction tends constantly to draw the planes of the equinoctial and ecliptic nearer together, what is to prevent them from coinciding in one and the same plane? How much is the distance or angle between them diminished every year? *What was the obliquity of the ecliptic, or the quantity of this angle, at the commencement of the present century? Is the annual diminution of the obliquity subject to any variation?*

This diminution, however, is subject to a slight semi-annual variation, from the same causes which produce the displacement of the plane of the ecliptic, in precession.

The attraction of the Sun and Moon, also, unites with that of the planets, at certain seasons, to augment the diminution of the obliquity, and at other times, to lessen it. On this account the obliquity itself is subject to a periodical variation; for the attractive power of the Moon, which tends to produce a change in the obliquity of the ecliptic, is *variable*, while the diurnal motion of the Earth, which tends to prevent the change from taking place, is *constant*. Hence the Earth, which is so nicely poised on her center, *bows* a little to the influence of the Moon, and rises again, alternately, like the gentle oscillations of a balance. This curious phenomenon, is called *Nutation*.

In consequence of the yearly diminution of the obliquity of the ecliptic, the tropics are slowly and steadily approaching the equinoctial, at the rate of little more than three fourths of a second every year; so that the Sun does not now come so far north of the equator in summer, nor decline so far south in winter, by nearly a degree, as it must have done at the creation.

The most obvious effect of this diminution of the obliquity of the ecliptic, is to equalize the length of our days and nights; but it has an effect also to change the position of the stars near the tropics. Those which were formerly situated north of the ecliptic, near the summer solstice, are now found to be still farther north, and farther from the plane of the ecliptic. On the contrary, those which, according to the testimony of the ancient astronomers, were situated south of the ecliptic, near the summer solstice, have approached this plane, insomuch that some are now either situated within it, or just on the north side of it. Similar changes have taken place with respect to those stars situated near the winter solstice. All the stars, indeed, participate more or less in this motion, but *less*, in proportion to their proximity to the equinoctial.

It is important, however, to observe, that this diminution will not always continue. A time will arrive when this motion, growing less and less, will at length entirely cease, and the obliquity will, apparently, remain constant for a time; after which it will gradually increase again, and con-

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From what cause? What effect has the attraction of the Sun and Moon on this obliquity? What results from this alternate and opposite influence? By what token does the Earth show respect to this influence of the Moon? What is this phenomenon called? What is the consequence of the yearly diminution of the obliquity of the ecliptic in respect to the position of the tropics, and the declination of the Sun? What other obvious effects result from this diminution? How does it affect the declination of the stars near the solstices? Do *all* the stars partake, more or less in this motion? Will this diminution of the obliquity always continue?

tinue to diverge by the same yearly increment as it before had diminished. This alternate decrease and increase will constitute an endless oscillation, comprehended between certain fixed limits. Theory has not yet enabled us to determine precisely what these limits are, but it may be demonstrated from the constitution of our globe, that such limits exist, and that they are very restricted, probably not exceeding 2° 42′. If we consider the effect of this ever-varying attribute in the system of the universe, it may be affirmed that the plane of the ecliptic never has coincided with the plane of the equator, and never will coincide with it. Such a coincidence, could it happen, would produce upon the Earth perpetual spring.

The method used by astronomers to determine the obliquity of the ecliptic is, to take half the difference of the greatest and least meridian altitudes of the Sun.

The following table exhibits the mean obliquity of the ecliptic for every ten years during the present century.

1800	23° 27′ 54″ .78	1860	23° 27′ 27″ .36
1810	23 27 50 .21	1870	23 27 22 .79
1820	23 27 45 .64	1880	23 27 18 .22
1830	23 27 41 .07	1890	23 27 13 .65
1840	23 27 36 .50	1900	23 27 09 .08
1850	23 27 31 .93	1910	23 27 04 .52

CHAPTER XXIII.

THE TIDES.

The oceans, and all the seas, are observed to be incessantly agitated for certain periods of time, first from the east towards the west, and then again from the west towards the east. In this motion, which lasts about six hours, the sea gradually swells; so that entering the mouth of rivers, it drives back the waters towards their source. After a continual flow of six hours, the seas seem to rest for about a quarter of an hour; they then begin to ebb, or retire back again from west to east for six hours more; and the rivers again resume their natural courses. Then after a seeming pause of a quarter of an hour, the seas again begin to flow, as before, and thus alternately. This regular alternate mo-

What are the *limits* of its alternate variation? What would be the consequence, in respect to the seasons, should the plane of the ecliptic ever coincide with the plane of the equator? What is the method used by astronomers for determining the obliquity of the ecliptic? What regular motion is observed in the great body of waters upon the globe? In what periods of time is this alternate ebbing and flowing accomplished?

tion of the sea constitutes *the tides*, of which there are two in something less than twenty-five hours.

The ancients considered the ebbing and flowing of the tides as one of the greatest mysteries in nature, and were utterly at a loss to account for them. Galileo and Descartes, and particularly Kepler, made some successful advances towards ascertaining the cause; but Sir Isaac Newton was the first who clearly showed what were the chief agents in producing these motions.

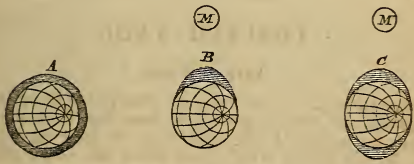
The cause of the tides, is the attraction of the Sun and Moon, but chiefly of the Moon, upon the waters of the ocean. In virtue of gravitation, the Moon, by her attraction, draws, or raises the water towards her; but because the power of attraction diminishes as the squares of the distance increase, the waters on the opposite side of the Earth are not so much attracted as they are on the side nearest the Moon.

That the Moon, says Sir John Herschel, should, by her attraction, heap up the waters of the ocean under her, seems to most persons very natural; but that the same cause, should, at the same time, heap them up on the opposite side, seems, to many, palpably absurd. Yet nothing is more true, nor indeed more evident, when we consider that it is not by her *whole* attraction, but by the differences of her attractions at the opposite surfaces and at the center, that the waters are raised.

That the tides are dependent upon some known and determinate laws, is evident from the exact time of high water being previously given in every ephemeris, and in many of the common almanacs.

The Moon comes every day later to the meridian than on the day preceding, and her exact time is known by calculation; and the tides in any and every place, will be found to follow the same rule; happening exactly so much later every day as the Moon comes later to the meridian. From this exact conformity to the motions of the Moon, we are induced to look to her as the cause; and to infer that these phenomena are occasioned principally by the Moon's attraction.

CAUSE OF THE TIDES.

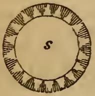


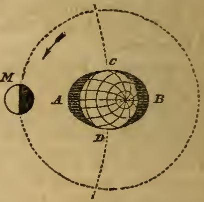
If the Earth were at rest, and there were no attractive influence from either the Sun or Moon, it is obvious from the principles of gravitation, that the waters in the ocean would be truly spherical, as represented at A; but daily observation proves that they are in a state of continual agitation.

What is it called? *How were these phenomena regarded by the ancients? Who ascertained their true cause?* What is the cause of the tides? How does the attraction of the Sun and Moon produce tides upon both sides of the Earth at the same time? *What is Sir John Herschel's remark upon this theory? How is it known that the tides are governed by any ascertained law? What coincidence is observed between the meridian passage of the Moon, and the time of high water? What conclusion may we derive from this coincidence?* If the Earth were at rest, and under no influence from the attraction of the Sun or Moon, what shape would the waters assume?

If the Earth and Moon were without motion, and the Earth covered all over with water, the attraction of the Moon would raise it up in a heap, in that part of the ocean under the Moon, as represented at B, and there it would, probably, always continue; but by the rotation of the Earth upon its axis, each part of its surface to which the Moon is vertical is presented to the action of the Moon; wherefore, as the quantity of water on the whole Earth remains the same, when the waters are elevated on the side of the Earth under the Moon, and on the opposite side also, it is evident they must recede from the intermediate points, and thus the attraction of the Moon produce *high water* at two opposite places, and *low water* at two opposite places, on the Earth, at the same time.

This is evident from the following figure. The waters cannot rise in one place without falling in another; and therefore they must fall as low in the horizon, at C and D, as they rise in the zenith and nadir, at A and B.





It has already been shown, under the article gravitation that the Earth and Moon would fall towards each other, by the power of their mutual attraction, if there were no centrifugal force to prevent them; and that the Moon would fall as much faster towards the Earth than the Earth would fall towards the Moon, as the quantity of matter in the Earth is greater than the quantity of matter in the Moon. The same law determines also the size of their respective orbits around their common center of gravity.

It follows then, as we have seen, that the Moon does not revolve, strictly speaking, around the Earth as a *center*, but around *a point between them*,

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Suppose the attractive power of the Moon upon the Earth to be as it is, and neither the Earth nor Moon to have any motion, what would be the result? How would this condition of things be affected by the Earth's rotation? If the Earth and Moon mutually attract each other with so much force, what prevents their coming together? But centrifugal force results only from circular motion, does the Earth then circulate around the *Moon* to acquire the centrifugal force by which it is kept from falling upon the Moon? [*Ans.* The Earth does not circulate around the *Moon*, but around the common center of gravity between it and the Moon.] Where is this center situated, and in what time does the Earth revolve about it? [*Ans.* The center of gravity, between the Earth and the Moon, is about 3000 miles from the Earth's center, around which it revolves every lunar month, or as often as the Moon revolves around the Earth.] *From the fact of the Earth's motion, as in the case described, how do some philosophers account for high water on the side of the Earth*, opposite *to the Moon?* How is this phenomenon otherwise explained, by the laws of gravity, merely? *Are the Earth and waters of the globe affected equally, by the Moon's attraction?* *Why not?*

which is 80 times nearer the Earth than the Moon, and consequently is situated about 3000 miles from the Earth's center. It has also been shown, that all bodies moving in circles acquire a centrifugal force proportioned to their respective masses and velocity. From these facts, some philosophers account for high water on the side of the Earth opposite to the Moon, in the following manner:—

As the Earth and Moon move around their common center of gravity, *that part of the Earth* which is at any time *turned from the Moon*, being about 7000 miles farther from the center of gravity, than the side next the Moon, would have a *greater centrifugal force than the side next her.* At the Earth's center, the centrifugal force will balance the attractive force; therefore as much water is *thrown off* by the centrifugal force on the side which is turned *from* the Moon, as is raised on the side next her by her attraction.

From the universal law, that the force of gravity diminishes as the square of the distance increases, it results, that the attractive power of the Moon decreases in intensity at every step of the descent from the zenith to the nadir; and consequently that the waters on the zenith, being more attracted by the Moon than the Earth is at its center, move faster towards the Moon than the Earth's center does: and as the cen er of the Earth moves faster towards the Moon than the waters about the nadir do, the waters will be, as it were, left behind, and thus, with respect to the center, they will be raised.

The reason why the Earth and waters of our globe do not seem to be affected *equally* by the Moon's attraction, is, that the earthy substance of the globe, being firmly united, does not yield to any difference of the Moon's attractive force; insomuch that its upper and lower surface must move equally fast towards the Moon; whereas the waters, cohering together but very lightly, yield to the different degrees of the Moon's attractive force, at different distances from her.

The length of a lunar day, that is, of the interval from one meridian passage of the Moon to another, being, at a mean rate, 24 hours, 48 minutes and 44 seconds, the interval between the flux and the reflux of the sea is not, at a mean rate, precisely six hours, but *twelve minutes and eleven seconds* more, so that the time of high water does not happen at the same hour, but is about 49 minutes later every day.

The Earth revolves on its axis in about twenty-four hours; if the Moon, therefore, were stationary, the same part of our globe would return beneath it, and there would be two tides every twenty-four hours; but while the Earth is turning once upon its axis, the Moon has gone forward 13° in her orbit—which takes forty-nine minutes more before the same meridian is brought again directly under the Moon. And hence every succeeding day the time of high water will be forty-nine minutes later than the preceding.

For example:—Suppose at any place it be high water at 3 o'clock in the afternoon, upon the day of new Moon, the following day it will be high water about 49 minutes after 3; the day after, about 38 minutes after 4; and so on till

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What is the average interval between the flux and reflux of the sea? What is the length of a lunar day, and of the interval of the flux and reflux of the sea? How is this daily retardation of the tides accounted for? *Give an example.*

the next new Moon. The exact daily mean retardation of the tides is thus determined:—

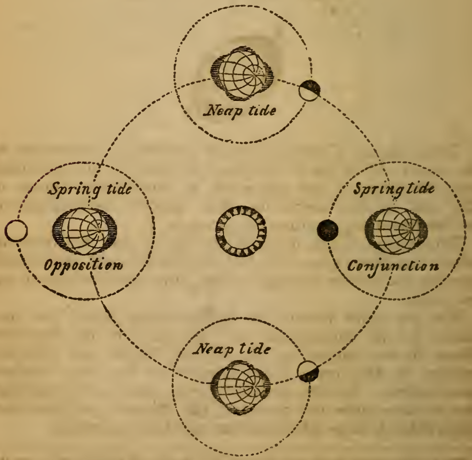
The mean motion of the Moon, in a solar day, is 13°.17639639
The mean motion of the Sun, in a solar day, is 0 .98564722

Now, as 15° is to 60 minutes, so is 12°.19074917 to 48′ 44″.

It is obvious that the attraction of the Sun must produce upon the waters of the ocean a like effect to that of the Moon, though in a less degree; for the great mass of the Sun is more than compensated by its immense distance. Nevertheless, its effect is considerable, and it can be shown, that the height of the solar tide is to the height of the lunar tide as 2 to 5. Hence the tides, though constant, are not equal. They are greatest when the Moon is in conjunction with, or in opposition to, the Sun, and least when in quadrature. For in the former case, the Sun and Moon act together, and the tide will equal the sum of the solar and lunar tides, and in the latter they act against each other, and the tide will be the difference.

The former are called *Spring Tides;* the latter, *Neap Tides.*

SPRING AND NEAP TIDES.

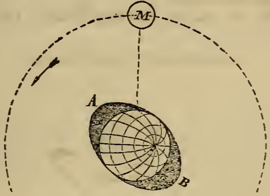


Are the tides uniformly high? When, and on what account, do they differ? What are these extreme tides called? When are the spring tides highest? When are the neap tides lowest?

The spring tides are highest, when the Sun and Moon are near the equator, and the Moon at her least distance from the Earth. The neap tides are lowest, when the Moon in her first and second quarters is at her greatest distance from the Earth. The general theory of the tides is this; When the Moon is nearest the Earth, her attraction is strongest, and the tides are the highest; when she is farthest from the Earth, her attraction is least, and the tides are the lowest.

From the above theory, it might be supposed that the tides would be the highest when the Moon was on the meridian. But it is found that in open seas, where the water flows freely, the Moon has generally *passed the north or south meridian about three hours, when it is high water.* This is called the

LAGGING OF THE TIDES IN LONGITUDE.



This lagging of the tide behind the Moon is illustrated by the above cut, in which the Moon is seen on the meridian, and the vertex of the tide-wave A, about three hours, or 22½° *east* of that meridian. The opposite wave is also in its corresponding position, as shown at B.

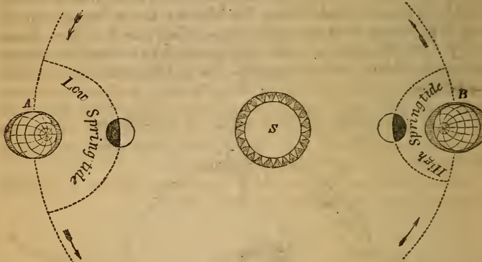
The reason of this delay of the tide is, that the force by which the Moon raises the tide *continues to act*, and consequently the waters continue to rise, after she has passed the meridian.

For the same reason, the highest tides, which are produced by the conjunction and opposition of the Sun and Moon, do not happen on the days of the full and change; neither do the lowest tides happen on the days of their quadratures. But the greatest *spring tides* commonly happen 1½ days *after* the new and full Moons; and the least *neap tides* 1½ *days after* the first and third quarters.

What is the general theory upon this subject? Does it necessarily result from this theory, that the tide is highest when the Moon is on the meridian? What reason is assigned for this? What similar fact is accounted for upon the same principle?

The Sun and Moon, by reason of the elliptical form of their orbits, are alternately nearer to and farther from the Earth, than their mean distances. In consequence of this, the efficacy of the Sun will fluctuate between the extremes 19 and 21, taking 20 for its mean value, and between 43 and 59 for that of the Moon. Taking into account this cause of difference, the highest spring tide will be to the lowest neap as 59+21 is to 43—19, or as 80 to 24, or 10 to 3. The relative *mean* influence is as 51 to 20, or as 5 to 2, *nearly.—Herschel's Astr. p.* 339.

The cause of this variation of the tides is illustrated in the following cut, in which the Earth and Moon are both shown as revolving in elliptical orbits.



At B, both the Earth and Moon are in *Perigee*, consequently the Sun and Moon will both exert their greatest attractive influence upon the Earth, and there will be the highest possible tide.

At A the Earth and Moon are in *Apogee*, and though the Sun and Moon are in conjunction, and unite their attractive forces the same as at B, to produce a *spring tide*, yet, as they are both at their greatest distance from the Earth, they exert their least possible influence, and the result is a moderate spring tide, as shown in the figure.

Though the tides, in *open seas*, are at the highest about *three hours* after the Moon has passed the meridian, yet the waters in their passage through shoals and channels, and by striking against capes and headlands, are so retarded that, to different places, the tides happen at all distances of the Moon from the meridian; consequently at all hours of the lunar day.

EXCURSION OF THE TIDES IN LATITUDE.

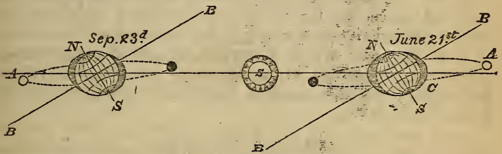
The vertices of the tide-wave are subject to *variations in latitude*, owing to the changes in the position of the Sun and

What is the comparative force of the solar and lunar attraction upon the Earth? To what is owing the great difference in the time of high water at places lying under the same meridian? What is meant by the Sun's *declination*? By what is it caused?

Moon, as respects the equator. The inclination of the Earth's axis to the ecliptic, and her revolution around the Sun, cause him to appear to oscillate north and south from tropic to tropic once and back every year. This is what is called his *declination.* It is *northern* or *southern*, according as he is north or south of the equator, and is reckoned in degrees from that point. Of course it can never exceed 23° 28,″ the amount of the polar inclination to the ecliptic.

But at the same time that the Sun appears to move, first north and then south of the equator, it is evident that he still remains in the *ecliptic*, from which the Moon next departs more than 5° 9″. Whenever, therefore, the Sun has great *southern* declination, as, for instance, at the time of the winter solstice, the Moon also must be far south at the time of her conjunction with him, or at new Moon; and as both these causes of the tides are south of the equator, the vertex of the tide-wave just east of their meridian will be in the *southern hemisphere*, and the one on the opposite side of the Earth in the *northern hemisphere.*

In the following diagram the excursion of the tide-wave *in latitude*, is represented to the eye.



Let the line A A represent the plane of the ecliptic, B B the *equinoctial*, or plane of the Earth's equator, &c. On the 21st of June the Sun is vertical over the *Northern tropic*, and at new Moon the highest tide-wave in the northern hemisphere will be about three hours after the Sun crosses the meridian. At the same time the opposite wave will be in the southern hemisphere, as shown at C.

On the 23d of Sept. the Sun and Moon are far *south* at conjunction; the tide-wave following them is highest in the southern hemisphere, and the opposite wave smaller over the northern. If, then, the southern vertex be three hours behind the Sun, as shown on page 289, or comes to the meridian at 3 o'clock P. M., the opposite wave which is twelve

What is its greatest extent? Is the Sun still in the ecliptic when 23° 28″ from the equinoctial? How far can the Moon depart from the ecliptic? Where must the Moon be, then, at conjunction, when the Sun has great southern declination? What effect does this have upon the tides? At what time do we have the highest tides at the north in summer? When, in winter?

hours behind it, must come to the same meridian about 3 o'clock in the morning. It is on this account, that in high latitudes every alternate tide is higher than the intermediate ones. the evening tides in summer exceeding the morning tides. and the morning tides in winter exceeding those of the evening.

TIDES IN INLAND SEAS, LAKES, ETC.

In small collections of water, the Moon acts at the same time on every part, diminishing the gravity of the whole mass. On this account there are no sensible tides in lakes, they being generally so small that when the Moon is vertical, it attracts every part alike; and by rendering all the waters equally light, no part of them can be raised higher than another. The Mediterranean and Baltic seas have very small elevations, partly for this reason, and partly because the inlets by which they communicate with the ocean are so narrow, that they cannot, in so short a time, either receive or discharge enough, sensibly to raise or sink their surfaces.

Of all the causes of difference in the height of tides at different places, by far the greatest is local situation. In wide-mouthed rivers, opening in the direction of the stream of the tides, and whose channels are growing gradually narrower, the water is accumulated by the contracting banks, until in some instances it rises to the height of 20, 30, and even 50 feet.

ATMOSPHERICAL TIDES.

Air being lighter than water, and the surface of the atmosphere being nearer to the Moon than the surface of the sea, it cannot be doubted but that the Moon raises much higher tides in the atmosphere than in the sea. According to Sir John Herschel these tides are, by very delicate observations, rendered not only sensible, but *measurable*.

Upon the supposition that there is water on the surface of the Moon of the same specific gravity as our own, we might easily determine the height to which the Earth would raise a lunar tide, by the known principle, that the attraction of one of these bodies on the other's surface is *directly* as its quantity of matter, and *inversely* as its diameter. By making the calculation, we shall find the attractive power of the Earth upon the Moon to be 21.777 times greater than that of the Moon upon the Earth.

Why are there no tides upon lakes, and small collections of water? To what cause, more than to all others, is the different height of tides owing? Explain this. Is it probable that the Moon exerts any influence of attraction on the atmosphere? Why is it probable? Are the atmospheric tides sufficiently sensible to be appreciated?

CHAPTER XXIV.

THE SEASONS—DIFFERENT LENGTHS OF THE DAYS AND NIGHTS.

The vicissitudes of the seasons and the unequal lengths of the days and nights, are occasioned by the annual revolution of the Earth around the Sun, with its axis inclined to the plane of its orbit.

The temperature of any part of the Earth's surface depends mainly, if not entirely, upon its exposure to the Sun's rays. Whenever the Sun is *above* the horizon of any place, that place is *receiving* heat; when the Sun is *below* the horizon it is parting with it, by a process which is called radiation. The quantities of heat thus received and imparted in the course of the year, must balance each other at every place, or the equilibrium of temperature would not be supported.

Whenever, then, the Sun remains more than twelve hours above the horizon of any place, and less beneath, the general temperature of that place will be *above* the mean state; when the reverse takes place, the temperature, for the same reason, will be *below* the mean state. Now the continuance of the Sun above the horizon of any place, depends entirely upon his declination, or altitude at noon. About the 20th of March, when the Sun is in the vernal equinox, and consequently has no declination, he rises at six in the morning and sets at six in the evening; the day and night are then equal, and as the Sun continues as long above our horizon as below it, his influence must be nearly the same at the same latitudes, in both hemispheres.

From the 20th of March to the 21st of June, the days grow longer, and the nights shorter, in the northern hemisphere the temperature increases, and we pass from spring to mid-summer; while the reverse of this takes place in the southern hemisphere. From the 21st of June to the 23d of September, the days and nights again approach to equality, and the excess of temperature in the northern hemisphere above the mean state, grows less, as also its defect in the southern; so that, when the Sun arrives at the autumnal

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How much greater is the attractive power of the Earth upon the Moon, than that of the Moon upon the Earth? What occasions the vicissitudes of the seasons, and the unequal lengths of the days and nights? Upon what does the temperature at different places depend? Under what circumstances do the same places change their temperature? Are the quantities of heat received and imparted, every year always equal at the same places? Why is it so? When is the temperature of a place *above*, and when is it *below* its mean state? Upon what does the continuance of the Sun above the horizon of any place, depend? When is the Sun as long above our horizon as below it? During what season of the year is the temperature increasing? What, at the same time, takes place in regard to the temperature, in the southern hemisphere? During what portion of the year is the temperature decreasing?

equinox, the mean temperature is again restored. From the 23d of September until the 21st of December, our nights grow longer and the days shorter, and the cold increases as before it diminished, while we pass from autumn to mid-winter, in the northern hemisphere, and the inhabitants of the southern hemisphere from spring to mid-summer. From the 21st of December to the 20th of March, the cold relaxes as the days grow longer, and we pass from the dreariness of winter to the mildness of spring, when the seasons are completed, and the mean temperature is again restored. The same vicissitudes transpire, at the same time, in the southern hemisphere, but in a contrary order. Thus are produced the four seasons of the year.

But I have stated not the only, nor, perhaps, the most efficient cause in producing the heat of summer and the cold of winter. If, to the inhabitants of the equator, the Sun were to remain 16 hours below their horizon, and only 8 hours above it, for every day of the year, it is certain they would never experience the rigors of our winter; since it can be demonstrated, that as much heat falls upon the same area from a *vertical* Sun in 8 hours, as would fall from him, at an angle of 60°, in 16 hours.

Now as the Sun's rays fall *most obliquely when the days are shortest*, and *most directly when the days are longest*, these two causes, namely, the duration and intensity of the solar heat, together, produce the temperature of the different seasons. The reason why we have not the hottest temperature when the days are longest, and the coldest temperature when the days are shortest, but in each case about a month afterwards, appears to be, that a body once heated, does not grow cold instantaneously, but gradually, and so of the contrary. Hence, as long as more heat comes from the Sun by day than is lost by night, the heat will increase, and *vice versa*.

BEGINNING AND LENGTH OF THE SEASONS.

					h. m. s.	
Sun enters	♑	(Winter begins)	1849,	Dec. 21,	7 25 46	M.T.Wash.
" "	♈	(Spring ")	1850,	March 20,	8 56 38	" "
" "	♋	(Summer ")	"	June 21st,	6 3 9	" "
" "	♎	(Autumn ")	"	Sept. 22d,	19 58 21	" "
" "	♑	(Winter ")	"	Dec. 21,	13 21 57	" "

For what reason? During what portion of the year is the cold increasing? Why is it so? What change of seasons, then, takes place, in the northern and southern hemispheres? What other changes complete the seasons of the year? Whence is it evident that the unequal lengths of the days and nights are not the only, nor perhaps the most efficient cause of the heat of summer, and the cold of winter? What two causes produce the greatest vicissitudes of heat and cold? Why, then, do we not have the hottest weather when the days are longest, and the contrary?

	d.	h.	m.	s.
Sun in the Winter Signs	89	1	30	52
" " Spring	92	21	6	31
" " Summer	93	13	55	22
" " Autumn	89	17	23	26
" north of Equator (Spring and Summer)	186	11	1	53
" south " (Winter and Autumn)	178	18	54	18
Longest north of the Equator, . . .	7	16	7	35
Length of the tropical year, beginning at the winter solstice 1849, and ending at the winter solstice 1850,	365	5	56	11
Mean or average length of the tropical year,	365	5	48	48

The north pole of the Earth is denominated the *elevated* pole, because it is always about 23½° above a perpendicular to the plane of the equator, and the south pole is denominated the *depressed* pole, because it is about the same distance below such perpendicular.

As the Sun cannot shine on more than one half the Earth's surface at a time, it is plain, that when the Earth is moving through that portion of its orbit which lies *above* the Sun, the elevated pole is in the dark. This requires six months, that is, until the Earth arrives at the equinox, when the elevated pole emerges into the light, and the depressed pole is turned away from the Sun for the same period. Consequently, there are six months day and six months night, alternately, at the poles.

When the Sun appears to us to be in one part of the ecliptic, the Earth, as seen from the Sun, appears in the point diametrically opposite. Thus, when the Sun appears in the vernal equinox at the first point of Aries, the Earth is actually in the opposite equinox at Libra. The days and nights are then equal all over the world.

As the Sun appears to move up from the vernal equinox to the summer solstice, the Earth actually moves from the autumnal equinox down to the winter solstice. The days now lengthen in the northern hemisphere, and shorten in the southern. The Sun is now over the north pole, where it is mid-day, and opposite the south pole, where it is midnight.

As the Sun descends from the summer solstice towards the autumnal equinox, the Earth ascends from the winter solstice towards the vernal equinox. The summer days in the northern hemisphere having waxed shorter and shorter, now become again of equal length in both hemispheres.

While the Sun appears to move from the autumnal equinox down to the winter solstice, the Earth passes up from

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Why is the north pole denominated the elevated pole? Why is the south pole denominated the depressed pole? Why are there six months day and six months night, alternately at the poles? What is always the relative position of the Sun and Earth in the ecliptic? Give an example. When do the days lengthen in the northern hemisphere, and shorten in the southern? When is it mid-day at the north pole, and midnight at the south? When do the summer days in the northern hemisphere grow shorter and shorter?

the vernal equinox to the summer solstice; the south pole comes into the light, the winter days continually shorten in the northern hemisphere, and the summer days as regularly increase in length in the southern hemisphere.

While the Sun appears again to ascend from its winter solstice to the vernal equinox, the Earth descends from the summer solstice to the autumnal equinox. The summer days now shorten in the southern hemisphere, and the winter days lengthen in the northern hemisphere.

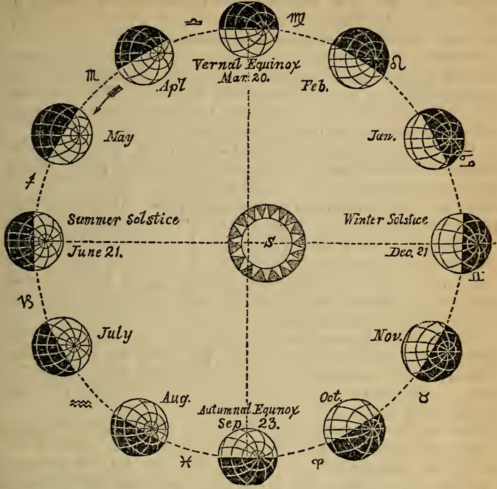
When the Sun passes the vernal equinox, it rises to the arctic or elevated pole, and sets to the antarctic pole. When the Sun arrives at the summer solstice, it is noon at the north pole, and midnight at the south pole. When the Sun passes the autumnal equinox, it sets to the north pole, and rises to the south pole. When the Sun arrives at the winter solstice, it is midnight at the north pole and noon at the south pole; and when the Sun comes again to the vernal equinox, it closes the day at the south pole, and lights up the morning at the north pole.

There would, therefore, be 186½ days during which the Sun would not set at the north pole, and an equal time during which he would not rise at the south pole; and 178½ days in which he would not set at the south pole, nor rise at the north pole.

At the arctic circle, 23° 27½′ from the pole, the longest day is 24 hours, and goes on increasing as you approach the pole. In latitude 67° 18′ it is 30 days; in lat. 69° 30′ it is 60 days, &c. The same takes place between the antarctic circle and the south pole, with the exception, that the day in the same latitude south is a little shorter, since the Sun is not so long south of the equator, as at the north of it. In this estimate no account is taken of the refraction of the atmosphere, which, as we shall see hereafter, increases the length of the day, by making the Sun appear more elevated above the horizon than it really is.

When do they become of equal length in both hemispheres? When do the winter days shorten in the northern hemisphere, and the summer days lengthen in the southern? When do the summer days shorten in the southern hemisphere, and the winter days lengthen in the northern? When does the Sun rise to the north pole, and set to the south? When is it noon at the north pole, and midnight at the south pole? When does the Sun set to the north pole, and rise to the south? When is it midnight at the north pole, and noon at the south? What is the length of the day at the north pole? What at the south pole? At the arctic circle? Between the antarctic circle and the pole?

THE SEASONS—UNEQUAL LENGTHS OF DAYS AND NIGHTS



The above cut represents the inclination of the earth's axis to its orbit in every one of the twelve signs of the ecliptic, and consequently for each month in the year. It is such a view as a beholder would have, situated in the north pole of the *ecliptic*, at some distance from it, and consequently, is a perpendicular view, the north pole of the Earth being towards us. The Sun enters the sign *Aries*, or the vernal equinox, on the 20th of March, when the Earth's axis inclines neither *towards* the Sun, nor *from* it, but stands exactly *sideways* to it; so that the Sun then shines equally upon the Earth from pole to pole, and the days and nights are every where equal. This is the beginning of the astronomical year; it is also the beginning of day at the north pole, which is just coming into light, and the end of day at the south pole, which is just going into darkness.

By the Earth's orbitual progress, the Sun appears to enter the second sign, *Taurus*, on the 20th of April, when the north pole has sensibly advanced into the light, while the south pole has been declining from it; whereby the days become longer than the nights in the northern hemisphere, and shorter in the southern.

On the 21st of May, the Sun appears to enter the sign *Gemini*, when the north pole has advanced considerably further into the light, while the south pole has proportionally declined from it; the summer days are now waxing longer in the northern hemisphere, and the nights shorter.

The 21st of June, when the Sun enters the sign *Cancer*, is the first day of summer in the astronomical year, and the longest day in the northern hemisphere. The north pole now has its greatest inclination to the Sun, the light of which, as is shown by the boundary of light and darkness, in the figure, extends to the utmost verge of the *Arctic Circle:* the whole of which is included in the enlightened hemisphere of the Earth, and enjoys, at this season, constant day during the complete revolution of the Earth on its axis. The whole of the Northern Frigid Zone is now in the circle of perpetual illumination.

On the 23d of July, the Sun enters the sign *Leo*, and as the line of the

Earth's axis always continues parallel to itself, the boundary of light and darkness begins to approach nearer to the poles, and the length of the day in the northern hemisphere, which had arrived at its maximum, begins gradually to decrease. On the 23d of August, the Sun enters the sign *Virgo*, increasing the appearances mentioned in *Leo*.

On the 23d of September, the Sun enters *Libra*, the first of the autumnal signs, when the Earth's axis having the same inclination as it had in the opposite sign, *Aries*, is turned neither *from* the Sun, nor *towards* it, but obliquely to it, so that the Sun again now shines equally upon the whole of the Earth's surface from pole to pole. The days and nights are once more of equal length, throughout the world.

On the 23d of October, the Sun enters the sign *Scorpio;* the days visibly decrease in length in the northern hemisphere, and increase in the southern.

On the 22d of November, the Sun enters the sign *Sagittarius*, the last of the autumnal signs, at which time the boundary of light and darkness is at a considerable distance from the north pole, while the south pole has proportionally advanced into the light; the length of the day continues to increase in the southern hemisphere, and to decrease in the northern.

On the 21st of December, which is the period of the winter solstice, the Sun enters the sign *Capricorn*. At this time, the north pole of the Earth's axis is turned from the Sun, into perpetual darkness; while the south pole, in its turn, is brought into the light of the Sun, whereby the whole *Antarctic* region comes into the circle of perpetual illumination. It is now that the southern hemisphere enjoys all those advantages with which the northern hemisphere was favored on the 21st of June; while the northern hemisphere, in its turn, undergoes the dreariness of winter, with short days and long nights. By carefully observing the figure, it will be seen that the orbit of the Earth is slightly elliptical, that the Sun is to the right of the center, and that consequently, the Earth is nearer the Sun on the 21st of December, than on the opposite side of the ecliptic, on the 21st of June. This may seem strange to the learner, that we should have our winter when nearest the Sun, and our summer when most distant; but it must be remembered, that the temperature of any particular part of the Earth is not so much affected by the *distance* of the Sun, as by the directness or obliquity of his rays. Hence, though we are farther from the Sun on the 21st of June than on the 21st of December, yet, as the north pole of the Earth is turned more directly into the light, at that time, so that the sun's rays strike her surface less obliquely than in December. we have a higher temperature at that period, though at a greater distance from the Sun.

The difference, however, between the aphelion and perihelion distances of the Earth, is so slight, in comparison with the whole distance, as scarcely to cause a *perceptible* difference in the amount of light received at her respective positions. The eccentricity of the Earth's orbit, or the distance of the Sun from its center, is only about 1,618,000 miles, so that the variation is only 3,236,000 miles, or about *one-thirtieth* of the mean distance. In the preceding cut the eccentricity is exaggerated to *one-eighth* the mean distance, making the difference between the Earth's perihelion and aphelion distance to amount to one quarter, or 23,777,777 miles. This is more than seven times its real amount, and yet the ellipticity is scarcely perceptible. The true orbit of the Earth could not be distinguished from a circle.

The only effect of the eccentricity of the earth's orbit upon her temperature is, that she has probably a greater degree of heat, during summer in the southern hemisphere, when the Earth is at her perihelion, than we ever have at the north in the same latitude. But this difference must be very slight, if indeed it is at all perceptible.

CHAPTER XXV.

HARVEST MOON—HORIZONTAL MOON.

The daily progress of the Moon in her orbit, from west to east, causes her to rise, at a mean rate, 48 minutes and 44 seconds later every day than on the preceding. But in places of considerable latitude, a remarkable deviation from this rule takes place, especially about the time of *harvest*, when the full Moon rises to us for several nights together, only from 18 to 25 minutes later in one day, than on that immediately preceding. From the benefit which her light affords, in lengthening out the day, when the husbandmen are gathering in the fruits of the Earth, the full moon, under these circumstances, has acquired the name of *Harvest Moon.*

It is believed that this fact was observed by persons engaged in agriculture, at a much earlier period than that in which it was noticed by astronomers. The former ascribed it to the goodness of the Deity; not doubting but that he had so ordered it for their advantage.

About the equator, the Moon rises throughout the year with nearly the equal intervals of 48¾ minutes; and there the harvest Moon is unknown.

At the polar circles, the autumnal full Moon, from her first to her third quarter, rises as the Sun sets; and at the poles, where the Sun is absent during one half of the year, the winter full Moons, from the first to the third quarter, shine constantly without setting.

By this, it is not meant that the Moon *continues full* from her first to her third quarter; but that she *never sets* to the North Polar regions, when, at this season of the year, she is within 90° of that point in her orbit where she is at her full. In other words: as the Sun illumines the south pole during one half of its yearly revolution, so the Moon, being *opposite* to the Sun at her full, must illumine the *opposite pole*, during half of her revolution about the Earth. The phenomenon of the harvest Moon may be thus exemplified by means of the globe:

Rectify the globe to the latitude of the place, put a patch or piece of wafer in the ecliptic, on the point Aries, and mark every 12° preceding and following that point, to the number of ten or twelve marks on each side of it; bring the equinoctial point marked by the wafer to the eastern edge of the horizon, and set the index to 12; turn the globe westward till the other marks successively come to the horizon, and observe the hours passed over by the index; the intervals of time between the marks coming to the horizon, will show the diurnal difference of time between the Moon's *rising*. If these marks be brought to the western edge of the horizon in the same manner, it will show the diurnal difference between the Moon's *setting*.

From this problem it will also appear, that, when there is the least difference between the times of the Moon's *rising*, there will be the greatest difference between the times of her *setting*, and the contrary.

What is the mean difference of time in the daily rising of the Moon? Under what circumstances is there a material deviation from this rule? Whence the name of *Harvest Moon*? *By whom was this phenomenon first observed, and to what did they attribute it?* Why is the harvest Moon unknown at the equator? How is it at the polar circles, and the poles? *What is meant by the full Moon's shining from the first to the third quarter? How may the phenomenon be exemplified by means of the artificial globe? Why do you mark every 12° of the ecliptic in this problem?*

The reason why you mark every 12° is, that the Moon gains 12° 11′ on the apparent course of the Sun every day, and these marks serve to denote the place of the Moon from day to day. It is true, this process supposes that the Moon revolves *in the plane of the ecliptic*, which is not the case; yet her orbit so nearly coincides with the ecliptic, (differing only 5° 9′ from it,) that they may, for the convenience of illustration, be considered as coinciding; that is, we may take the ecliptic for the representative of the Moon's orbit.

The different lengths of the lunar night, at different latitudes, is owing to the different angles made by the horizon and different parts of the Moon's orbit; or in other words, by the Moon's orbit lying sometimes more oblique to the horizon than at others. In the latitude of London, for example, as much of the ecliptic rises about Pisces and Aries in two hours as the Moon goes through in six days; therefore while the Moon is in these signs, she differs but two hours in rising for six days together; that is, one day with another, she rises about 20 minutes later every day than on the preceding.

The parts or signs of the ecliptic which *rise* with the *smallest* angles, *set* with the *greatest;* and those which rise with the greatest, set with the least. And whenever this angle is least, a greater portion of the ecliptic rises in equal times than when the angle is larger. Therefore, when the Moon is in those signs which rise or set with the smallest angles, she rises or sets with the least difference of time; but when she is in those signs which rise or set with the greatest angles, she rises or sets with the greatest difference of time.

Let the globe, for example, be rectified to the latitude of New York, 40° 42′ 40″, with Cancer on the meridian, and Libra rising in the east. In this position, the ecliptic has a high elevation, making an angle with the horizon of 72½°.

But let the globe be turned half round on its axis, till Capricorn comes to the meridian, and Aries rises in the east, then the ecliptic will have a low elevation above the horizon, making an angle with it of only 25½°. This angle is 47° less than the former angle, and is equal to the distance between the tropics.

In *northern* latitudes, the *smallest* angle made by the ecliptic and horizon is when Aries rises; at which time Libra sets; the *greatest* is, when Libra rises and Aries sets. The ecliptic rises fastest about Aries, and slowest about Libra. Though Pisces and Aries make an angle of only 25½° with the horizon *when they rise*, to those who live in the latitude of New York, yet the same signs, *when they set*, make an angle of 72½°. The daily difference of the Moon's rising, when in these signs, is, in New England, about 22

What does this process of illustration suppose, which is not true, and why is it adopted? To what is the different lengths of the lunar night, in different latitudes, owing? Give an example. How do those parts of the ecliptic *set*, which *rise* with the smallest angles, and the contrary?

What results from this in regard to the Moon? *How may this be illustrated on the globe?* In northern latitudes, what signs rise and set with the least angles? What with the greatest? Which parts of the ecliptic rise fastest, and which slowest? Give an example. What is the daily difference of the Moon's rising and setting, in these signs, in the latitude of New York?

minutes; but when she is in the opposite signs, Virgo and Libra, the daily difference of her rising is almost four times as great, being about one hour and a quarter.

As the Moon can never be full but when she is opposite to the Sun, and the Sun is never in Virgo or Libra except in our autumnal months, September and October, it is evident that the Moon is never full in the opposite signs, Pisces and Aries, except in those two months. We can therefore have only two full Moons in a year, which rise, for a week together, very near the time of Sun-set.—The former of these is called the *Harvest Moon*, and the latter, the *Hunter's Moon.*

Although there can be but two *full* Moons in the year that rise with so little variation of time, yet the phenomenon of the Moon's rising for a week together so nearly at the same time, occurs every month, in some part of her course or the other.

In *Winter*, the signs Pisces and Aries rise *about noon*; hence the rising of the Moon is not then regarded nor perceived.

In *Spring*, these signs *rise with the Sun*, because he is then in them; and as the Moon changes while passing through the same sign with the Sun, it must then be *the change*, and hence invisible.

In *Summer*, they rise about midnight, when the Moon is in her *third* quarter. On account of her rising so late, and giving but little light, her rising passes unobserved.

To the inhabitants at the equator, the north and south poles appear in the horizon; and therefore the ecliptic makes the same angle southward with the horizon when Aries rises, as it does northward when Libra rises; consequently the Moon rises and sets not only with angles nearly equal, but at equal intervals of time, all the year round; hence, there is no harvest Moon at the equator. The farther any place is from the equator, if it be not beyond the polar circles, the angle which the ecliptic makes with the horizon gradually diminishes when Pisces and Aries rise.

Although in northern latitudes, the autumnal full Moons are in Pisces and Aries; yet in southern latitudes it is just the reverse, because the seasons are so:—for Virgo and Libra rise at as small angles with the horizon in southern latitudes, as Pisces and Aries do in the northern; and therefore the harvest Moons are just as regular on one side of the equator as on the other.

At the polar circles, the full Moon neither rises in summer, nor sets in winter. For the winter full Moon being as high in the ecliptic as the summer Sun, she must continue, while

How many full Moons in a year, which rise with so little difference of time? *Why are not these phenomena observed in the same signs, in winter, spring, and summer?* Explain why there is no Harvest Moon at the equator. The farther any place is from the equator, how is the angle between the ecliptic and the horizon, when *Pisces* and *Aries* rise? Do the Harvest Moons happen as regularly, and in the same months, on the *south* side of the equator, as on the *north*? Why does not the full Moon rise in summer, or set in winter, to the inhabitants of the polar circles?

passing through the northern signs, *above* the horizon; and the summer full Moon being as *low* in the ecliptic as the winter Sun, can no more rise, when passing through the southern signs, than he does.

THE HORIZONTAL MOON.

The great apparent magnitude of the Moon, and indeed of the Sun, at rising and setting, is a phenomenon which has greatly embarrassed almost all who have endeavored to account for it. According to the ordinary laws of vision, they should appear to be least when nearest the horizon, being then farthest from the eye; and yet the reverse of this is found to be true. The apparent diameter of the Moon, when viewed in the horizon by the naked eye, is two or three times larger than when at the altitude of thirty or forty degrees; and yet when measured by an instrument her diameter is not increased at all.

Both the Sun and the Moon subtend a greater angle when on the meridian, than they do in the horizon, because they are then actually nearer the place of the spectator, by the whole semi-diameter of the Earth.

This apparent increase of magnitude in the horizontal Moon, is chiefly an optical illusion, produced by the concavity of the heavens appearing to the eye to be a less portion of a spherical surface than a hemisphere. The eye is accustomed to estimate the distance between any two objects in the heavens by the quantity of sky that appears to lie between them; as upon the Earth we estimate it by the quantity of ground that lies between them. Now when the Sun or Moon is just emerging above the eastern horizon, or sinking beneath the western, the *distance* of the intervening landscape over which they are seen, contributes, together with the *refraction* of the atmosphere to exaggerate our estimate of their real magnitudes.

CHAPTER XXVI.

REFRACTION—TWILIGHT.

THE rays of light in passing out of one medium into another of a greater density, deviate from a straight course, and are bent towards a perpendicular to that course; and

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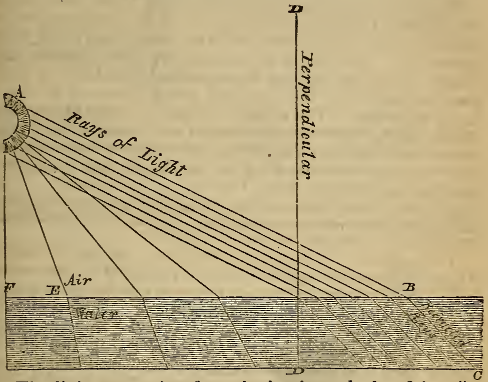
According to the ordinary laws of vision, how ought the magnitudes of the Sun and Moon to appear when they are nearest the horizon? What is the fact? How much larger does the Moon appear to the naked eye, when in the horizon, than when at the altitude of thirty or forty degrees? *Where, in reality, do the Sun and Moon subtend the largest angle? Why is it so?* How is the apparent increase of magnitude in the horizontal Moon accounted for?

if the density of the latter medium continually increase, the rays of light in passing through it, will deviate more and more from a right line as they pass downwards, or towards the eye of the observer. This principle is illustrated by the following cut.

REFRACTION OF LIGHT.



The light emanating from the luminous body of A strikes the water at B, and is bent out of its course towards the perpendicular D D. The rays B C are the *refracted rays*, and the angle they make at B the *angle of refraction*.

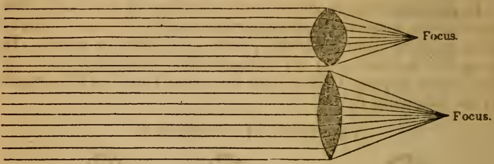
It will be seen further by the diagram that the amount of the angle of refraction is in proportion to the obliquity of the rays. At B they are more refracted than at E, and at F, where the light strikes the water perpendicularly, it is not refracted at all.

The principles here illustrated hold good in regard to all transparent substances, whether fluids or solids, and all kinds of surfaces. Glass will refract light as well as water, and a convex surface as well as a plain one; and in all cases the angle of incidence (or contact with the denser substance) and the angle of refraction are proportionate. Hence a lens made of glass, having two convex surfaces, will refract all the light that falls upon it, to a point called its focus, in the center, which point will be near or remote, according to the

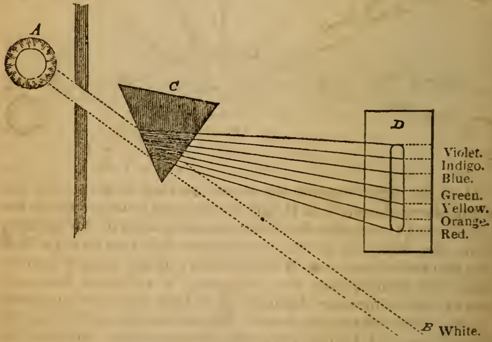
How are the rays of light affected in passing out of one medium into another, of a different density? How, if the density of the latter medium continually increase?

convexity or flatness of the lens. The annexed cut furnishes the necessary illustration.

LIGHT REFRACTED BY GLASS LENSES.



By sending a beam of light through a triangular piece of glass, called a *prism*, it is found that all parts of the beam are not refracted alike, or in other words that light is a compound substance, some of whose elements are more refrangible than others. The *red* light is refracted least, the *orange* next, and so on to *violet*, the most refrangible of all the primary colors.



In the cut the light from A instead of passing in straight lines to B, is refracted by the prism C towards the point D; and thus, by the difference of their refrangibility, the component parts of the white beam are separated.

In a similar manner the light is analyzed by refraction in the formation of the rainbow, and also in the production of

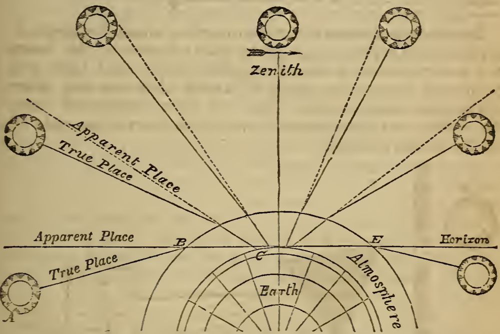
What astronomical phenomenon results from this cause? What is this bending of the rays of light out of their course called?

the various tints that often adorn the morning and evening sky.

ATMOSPHERICAL REFRACTION.

In passing from its source to the surface of the earth, the light of the heavenly bodies is refracted by the atmosphere, as in passing from the atmosphere into glass or water. It is on this account that all celestial bodies, except when in the zenith *appear higher* than they really are, as illustrated in the following figure.

ATMOSPHERICAL REFRACTION.



Here the light emanating from the Sun at A, strikes the atmosphere obliquely at B, and is refracted downwards to the beholder at C; so that the Sun is actually seen in the horizon, or in the direction of the last line of light, before he has reached that elevation. A little farther up, the light is seen to strike the atmosphere less obliquely, is refracted less, and leaves less difference between the *true* and the apparent place. Still nearer the zenith the refraction is still less, till finally, the rays falling perpendicularly are not refracted at all. From the zenith westward, the refraction and consequent difference between the Sun's true and apparent place increases, till at E the Sun is seen after he is below the horizon.

At some periods of the year the Sun appears 5 minutes longer, morning and evening, and about 3¼ minutes longer

What effect does refraction have upon the apparent rising and setting of the heavenly bodies? How much longer do we see the Sun, morning and evening, than we should if there were no refraction?

every day, at a mean rate, than he would do were there no refraction. The average amount of refraction for an object half way between the horizon and the zenith, or at an apparent altitude of 45°, is but *one sixtieth* of a degree, a quantity hardly sensible to the nâked eye; but at the visible horizon it amounts to 33′ of a degree, which is rather more than the greatest apparent diameter of either the Sun or the Moon.

Hence it follows, that when we see the lower edge of the Sun or Moon just *apparently* resting on the horizon, their whole disc is in reality below it, and would be entirely out of sight and concealed by the convexity of the Earth, but for the bending, which the rays of light have undergone in their passage through the air to the observer's eye.

The following general notions of its amount, and law of variations, should be borne in mind:

1. In the *zenith* there is no refraction; a celestial object, situated directly overhead, is seen in its true position, as if there were no atmosphere.

2. In descending from the *zenith* to the horizon, the refraction continually increases; objects near the horizon appearing more elevated by it than those of a higher altitude.

3. The *rate* of its increase is nearly in proportion to the apparent angular distance of the object from the zenith. But this rule, which is not far from the truth, at moderate *zenith distances*, ceases to give correct results in the vicinity of the horizon, where the law becomes much more complicated in its expression.

The effects of refraction must be familiar to every person who has seen a walking-stick partially plunged into a river, or other collection of water. While the stick is held upright, it appears straight, as usual, because there is no refraction in this position; but if it be ever so little inclined, the refraction takes place, and the stick appears bent; if the inclination be increased, the refraction is also increased.

Another easy and familiar illustration of the effect of refraction may be thus obtained:—Put any small object, as a piece of money, into an empty basin, as near the center as possible, and retire to such a distance as just to lose sight of the object. Let an assistant then pour water in the basin, and the object will soon reappear. Retire again till it is no longer seen; let more water be added, and it will again appear. The experiment may be repeated till the basin is full The edge of the basin may be supposed to represent the horizon; the water, the atmosphere; and the piece of money, the Sun, or other object which is thus made to appear by the power of refraction, when otherwise it would be invisible.

In this illustration, the light from the object at A, is intercepted by the side of the empty vessel at B, so that it remains invisible to the beholder on the right; but when the vessel is filled with water, the light from the object on reach-

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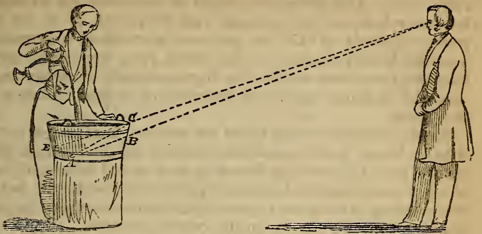
What is the average amount of refraction for an object half way between the horizon and the zenith? What is it in the horizon? What interesting facts result from this truth? What is the first general law of atmospheric refraction? What is the second general law? What is the third? *Mention a familiar instance of refraction often seen in water. Mention some familiar experiment, to illustrate refraction, and show its application to astronomy.*

CURIOUS RESULT OF REFRACTION.



ing the surface at C, is refracted in a horizontal direction; and by its thus reaching the eye of the observer the object is rendered visible, though the side of the vessel actually intervenes between it and him.

From what has been said of the amount of refraction when the luminous body is in or near the horizon, it must be obvious that one of its effects must be to shorten the duration of night and darkness, by prolonging the apparent stay of the Sun and Moon above the horizon. But even after they appear to have set, the influence of the atmosphere still continues to send us a portion of their light; not, indeed, by direct transmission, but by *reflection*:—for as long as the Sun continues to illuminate any portion of the atmosphere which is above the horizon, the light from this portion is reflected to the Earth, and it is this that causes twilight.

In the morning, when the Sun arrives at 18° below the horizon, his rays pass over our heads into the higher region of the atmosphere, and are thence *reflected*, or as it were, *bent down* to the Earth. The day is then said to *dawn*, and the light gradually increases until the Sun appears above the horizon: this is called *Morning Twilight*, or *Aurora*, which the heathens personified as a goddess. They assigned to her the office of opening the Gates of the East, to introduce the chariot of *Apollo* or *Phœbus*.

In the evening, after sunset, the rays of the Sun continue to illuminate the atmosphere, till he sinks 18° below the horizon, and a similar effect, called the *Evening Twilight*, is produced, only in an inverse progression, for the twilight now gradually becomes fainter till it is lost in dark night.

The quantity of reflection and the duration of twilight

How does this principle affect the duration of nocturnal darkness? By what principle is it that the atmosphere sends us a portion of the solar light, for a considerable time before the Sun rises, and after it has set? What is *Twilight*? How is it occasioned? How is the evening twilight produced? By what are the quantity of reflection, and the duration of twilight, considerably influenced? Why is twilight shorter in winter?

are much influenced by the changes which are perpetually taking place with respect to the heat and cold, the dryness or moisture, &c., of the atmosphere. The height of the atmosphere, also, has an influence in determining the duration of twilight. Thus in winter, when the air is condensed with cold, and the atmosphere upon that account *lower*, the twilight will be *shorter;* and in summer, when the limits of the atmosphere are extended by the rarefaction and dilation of the air of which it consists, the duration of the twilight will be longer. And for the same reason, the morning twilight, (the air being at that time condensed and contracted by the cold of the preceding night) will be shorter than the evening twilight, when the air is more dilated and expanded.

It is entirely owing to the *reflecting power* of the atmosphere that the heavens appear bright in the day-time. For without such a power, only that part of the heavens would be luminous in which the Sun is placed; and, if we should turn our backs to the Sun, the whole heavens would appear as dark as in the night, and the stars, even at noon-day, would be seen as clear as in the nocturnal sky.

In regions of the Earth situated towards the poles, the Sun, during their summer months, is never more than 18° below the horizon; consequently their twilight continues during the whole night. The same cause has a tendency to diminish the gloom of the long polar nights; for as far north as in lat. 84° 32½′ the Sun, even when at the winter solstice, approaches to within 18° of the horizon, and affords a short twilight once in 24 hours, and the pole itself is left in *total* darkness not more than 80 days.

There is still another cause which has a tendency to diminish the length of the polar nights, the extraordinary refraction occasioned by the extreme density of the air in those regions. This is so great, as to bring the Sun above the horizon some days before it should appear, according to calculation.

A remarkable phenomenon of this kind was observed by the Dutch navigators who wintered in Nova Zembla, in the year 1596. After enduring a continual night of *three months*, they were agreeably surprised to find that the Sun began to rise *seventeen days sooner* than according to computation! The observed altitude of the pole at the place, (says Dr. Smith,) being only 76°, it is impossible to account for the phenomenon, otherwise, than by supposing an extraordinary refraction of the Sun's rays. Kepler computes that the Sun was almost 5° below the horizon when he first appeared; and consequently, that the refraction of his rays was about 10 times greater than with us.

Why longer in summer? Why is the morning twilight shorter than the evening twilight? To what is it entirely owing, that the heavens appear bright in the day-time? How would the heavens appear, if it were not for this power? What are the duration and advantages of twilight in high latitudes? *Relate a remarkable phenomenon of this kind.* How are the phenomena of the Aurora Borealis regarded by the ignorant? In what do all agree, respecting them? Where are these appearances most frequent and brilliant? Describe the times and manner of their appearance

CHAPTER XXVII.

AURORA BOREALIS.

THE sublime and beautiful phenomena presented by the *Aurora Borealis*, or *northern lights*, as they are called, have been in all ages a source of admiration and wonder alike to the peasant and the philosopher. In the regions of the north, they are regarded by the ignorant with superstitious dread, as harbingers of evil; while all agree in placing them among the unexplained wonders of nature.

These lights, or meteoric coruscations, are more brilliant in the arctic regions, appearing mostly in the winter season and in frosty weather. They commonly appear at twilight near the horizon, and sometimes continue in that state for several hours without any sensible motion; after which they send forth streams of stronger light, shooting with great velocity up to the zenith, emulating, not unfrequently, the lightning in vividness, and the rainbow in coloring; and again, silently rising in a compact majestic arch of steady white light, apparently durable and immovable, and yet so evanescent, that while the beholder looks upon it, it is gone.

At other times, they cover the whole hemisphere with their flickering and fantastic coruscations. On these occasions their motions are amazingly quick, and they astonish the spectator with rapid changes of form. They break out in places where none were seen before, skimming briskly along the heavens; then they are suddenly extinguished, leaving behind a uniform dusky track, which, again, is brilliantly illuminated in the same manner, and as suddenly left a dull blank. Some nights they assume the appearance of vast columns; exhibiting on one side tints of the deepest yellow, and on the other, melting away until they become undistinguishable from the surrounding sky. They have generally a strong tremulous motion from end to end, which continues till the whole vanishes.

Maupertius relates, that in Lapland, "the sky was sometimes tinged with so deep a red that the constellation Orion looked as though it were dipped in blood, and that the people fancied they saw armies engaged, fiery chariots, and a thousand prodigies." *Gmelin* relates, that, "in Siberia, on the confines of the icy sea, the spectral forms appear like rushing armies; and that the hissing, crackling noises of

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Describe their appearance in Lapland as related by Maupertius, and its effect upon the inhabitants.

those aerial fire-works so terrify the dogs and the hunters, that they fall prostrate on the ground, and will not move while the raging host is passing."

Kerguelen describes "the night, between *Iceland* and the *Ferro* Islands, as brilliant as the day"—the heavens being on fire with flames of red and white light, changing to columns and arches, and at length confounded in a brilliant chaos of cones, pyramids, radii, sheaves, arrows, and globes of fire.

But the evidence of *Capt. Parry* is of more value than that of the earlier travelers, as he examined the phenomena under the most favorable circumstances, during a period of twenty-seven consecutive months, and because his observations are uninfluenced by imagination. He speaks of the shifting figures, the spires and pyramids, the majestic arches, and the sparkling bands and stars which appeared within the arctic circle, as surpassing his powers of description. They are indeed sufficient to enlist the superstitious feelings of any people not fortified by religion and philosophy.

The *colors* of the polar lights are of various tints. The *rays* or *beams* are steel gray, yellowish gray, pea green, celandine green, gold yellow, violet blue, purple, sometimes rose red, crimson red, blood red, greenish red, orange red, and lake red. The *arches* are sometimes nearly black, passing into violet blue, gray, gold yellow, or white bounded by an edge of yellow. The *lustre* of these lights varies in kind as well as intensity. Sometimes it is pearly, sometimes imperfectly vitreous, sometimes metallic. Its degree of intensity varies from a very faint radiance to a light nearly equaling that of the Moon.

Many theories have been proposed to account for this wonderful phenomenon, but there seems to be none which is entirely satisfactory. One of the first conjectures on record attributes it to inflammable vapors ascending from the Earth into the polar atmosphere, and there ignited by electricity. Dr. Halley objects to this hypothesis, that the cause was inadequate to produce the effect. He was of opinion that the poles of the Earth were in some way connected with the aurora; that the Earth was hollow, having within it a magnetic sphere, and that the magnetic effluvia, in passing from the north to the south, might become visible in the northern hemisphere.

Describe its appearance between Iceland and the Ferro Islands, as related by Kerguelen. Whose testimony on this subject is of more value than that of former travelers? Why? How does he describe the scenes he witnessed during the polar nights? Describe the *colors* of the Aurora light. What is one of the earliest theories advanced to explain this phenomenon? How did Dr. Halley propose to account for it? What observations have led pretty generally to the conclusion, that the northern lights are to some extent a magnetical phenomenon?

That the aurora borealis is, to some extent, a magnetical phenomenon, is thought, even by others, to be pretty clearly established by the following considerations.

1. It has been observed, that when the aurora appears near the northern horizon in the form of an arch, the middle of it is not in the direction of the true north, but in that of the magnetic needle at the place of observation; and that as the arch rises towards the zenith, it constantly crosses the heavens at right angles, not to the true *magnetic* meridian.

2. When the beams of the aurora shoot up so as to pass the zenith, which is sometimes the case, the point of their convergence is in the direction of the prolongation of the dipping needle at the place of observation.

3. It has also been observed, that during the appearance of an active and brilliant aurora, the magnetic needle often becomes restless, varies sometimes several degrees, and does not resume its former position until after several hours.

From these facts, it has been generally inferred that the aurora is in some way connected with the magnetism of the Earth; and that the simultaneous appearance of the meteor, and the disturbance of the needle, are either related as cause and effect, or as the *common result* of some more general and unknown cause. Dr. Young, in his lectures, is very certain that the phenomenon in question is intimately connected with electro-magnetism, and ascribes the *light* of the aurora to the illuminated agency of electricity upon the magnetical substance.

It may be remarked, in support of the electro-magnetic theory, that in magnetism. the agency of electricity is now clearly established; and it can hardly be doubted that the phenomena both of electricity and magnetism are produced by one and the same cause; inasmuch as magnetism may be induced by electricity, and the electric spark has been drawn from the magnet.

Sir John Herschel also attributes the appearance of the aurora to the agency of electricity. This wonderful agent, says he, which we see in intense activity in lightning, and in a feebler and more diffused form traversing the upper regions of the atmosphere in the northern lights, is present, probably, in immense abundance in every form of matter which surrounds us, but becomes sensible, only when disturbed by excitements of peculiar kinds.

What is the opinion of Dr. Young in regard to their cause? *What consideration may be adduced in farther support of the electro-magnetic theory?* To what does Sir John Herschel ascribe the aurora? What are his observations upon the subject? What is parallax? What is the true place of a celestial body? What is the *apparent* place? Where is the parallax of a heavenly body the greatest? What is this parallax called?

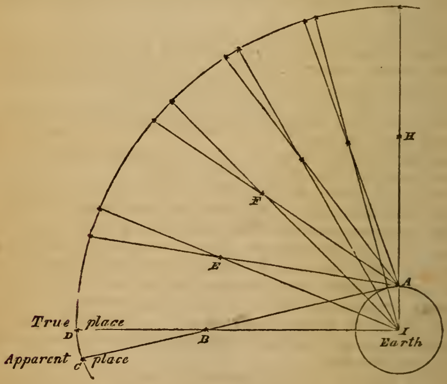
CHAPTER XXVIII.

PARALLAX OF THE HEAVENLY BODIES.

Parallax is the difference between the altitude of any celestial object, seen from the Earth's surface, and the altitude of the same object, seen at the same time from the Earth's center; or, it is the angle under which the semidiameter of the Earth would appear, as seen from the object.

The *true place* of a celestial body, is that point of the heavens in which it would be seen by an eye placed at the center of the Earth. The *apparent place* is that point of the heavens where the body is seen from the surface of the Earth. The parallax of a heavenly body is greatest, when in the horizon; and is called the *horizontal parallax*. Parallax decreases, as the body ascends toward the zenith, at which place it is nothing.

The following cut will afford a sufficient illustration.



PARALLAX.

When the observer, standing upon the Earth at A, views the object at B, it appears to be at C, when, at the same time, if viewed from the center of the Earth it would appear

How does the parallax of a body vary, with its altitude? How is it affected by *distance*? Give an example.

to be at D. The parallax is the angle B C D or B A I, which is the difference between the altitude of the object B, when seen from the Earth's surface, and when seen from her center. It is also the angle under which the semi-diameter of the Earth, A I, is seen from the object B.

As the object advances from the horizon to the zenith, the parallax is seen constantly to diminish, till at H, it has no parallax, or its apparent and true place are the same.

This diagram will also show why objects *nearest* the Earth have the *greatest* parallax, and those most distant the least—why the Moon, the nearest of all the heavenly bodies, has the greatest parallax, while the fixed stars, from their immense distance, have scarce any appreciable parallax, the semi-diameter of the Earth, at such a distance, being no more than a point.

As the effect of parallax on a heavenly body is to depress it *below its true place*, it must necessarily affect its right ascension and declination, its latitude and longitude. On this account the parallax of the Sun and Moon must be *added* to their *apparent* altitude, in order to obtain their *true* altitude.

The true altitude of the Sun and Moon, except when in the zenith, is always affected, more or less, both by parallax and refraction, but always in a contrary manner. Hence the mariner, in finding the latitude at sea, always *adds* the parallax, and *subtracts* the refraction, to and from the Sun's *observed* altitude, in order to obtain the *true* altitude, and thence the latitude.

The principles of parallax are of great importance to astronomy, as they enable us to determine the distances of the heavenly bodies from the Earth, the magnitudes of the planets, and the dimensions of their orbits.

The Sun's horizontal parallax being accurately known, the Earth's distance from the Sun becomes known; and the Earth's distance from the Sun being known, that of all the planets may be known also, because we know the exact periods of their sidereal revolutions, and according to the third law of Kepler, the squares of the times of their revolutions are proportional to the cubes of their mean distances. Hence, the first great desideratum in astronomy, where measure and magnitude are concerned, is the determination of the true parallax.

At the late council of astronomers, assembled in London, from the most learned nations in Europe, the Sun's mean horizontal parallax was settled, as the result of their united

What, then, are the necessary effects of parallax on the appearance of a heavenly body? How, then, can we obtain the true altitude of the Sun or Moon? *Do parallax and refraction affect the altitude alike? Give an example.* Why are the principles of parallax of great importance to astronomy? If the Sun's parallax be known, how may the distances of all the planets be known also? What inference may be derived from this in regard to the importance of parallax?

observations, at 0° 0′ 8″.5776. Now the value of radius, expressed likewise in seconds, is 206264″.8; and this divided by 8″.5776, gives 24047 for the distance of the Sun from the Earth, in semi-diameters of the latter. If we take the *equatorial* semi-diameter of the Earth as sanctioned by the same tribunal, at (7924÷2=) 3962 miles, we shall have 24047×3962=95,273,869 miles for the Sun's true distance.

Both the principle and the calculation of this element may be illustrated by a reference to the diagram on Plate 1 of the Atlas: Thus—the parallactic angle AES = 8″.5776: is to the Earth's semi-diameter as = 3962 miles:: as radius = 206264″.8: is to the distance ES = 95,273,869 miles, as before.

Again: The mean horizontal parallax of the Moon is 0° 57′ 11″, or 3431″. In this problem, the parallactic angle AMS is 0° 57′ 11″= 3431″; and 3431″: is to 3962 miles:: as 206264″.8: is to 238,161 miles, for the Moon's mean distance from the Earth MS.—*See Chapter on the Number and Distance of the Stars.*

CHAPTER XXIX.

PROBLEMS AND TABLES.

PROBLEM I.

TO CONVERT DEGREES, ETC., INTO TIME.

RULE 1.—Divide the degrees by 15, for hours; and multiply the remainder, if any, by 4, for minutes.

2. Divide the odd minutes and seconds in the same manner by 15 for minutes, seconds, &c., and multiply each remainder by 4, for the next lower denomination.

EXAMPLE 1.—Convert 32° 34′ 45″ into time.

Thus,	32° ÷ 15 =	2h. 8′		
	34 ÷ 15 =		2	16″
	45 ÷ 15 =			3
Ans.	32°34′45″ =	2h. 10′		19″ the time.

EXAMPLE 2.—If it is 12 o'clock at this place, what is the time 20° east of us?

Thus, fifteen in 20°, once, and five over; the *once* is 1 hour, and the 5 multiplied by 4, gives 20 minutes: the time is then 1 hour and 20 minutes past 12.

EXAMPLE 3.—The longitude of Hartford is 72° 50′ west of Greenwich; what time is it at Greenwich when it is 12 o'clock at Hartford? Ans. 4 h. 51 min. 20 sec.

EXAMPLE 4.—When it is 12 o'clock at Greenwich, what is the time at Hartford? Ans. 7h. 8m. 40 sec. A. M.

NOTE.—Table VIII. is designed to facilitate calculations of this kind. The degrees being placed in one column, and the corresponding time in another, it needs no explanation, except to observe that *degrees* in the left-hand columns may be considered as so many *minutes*, instead of degrees; in which case, the corresponding time in the adjoining column, must be read as *minutes* and *seconds*, instead of hours and minutes. In like manner, the degrees in the left-hand column may be read as seconds, and the corresponding time, as *seconds* and *thirds*.

EXAMPLE.—Find, by the table, the time corresponding to 32° 34′ 45″.

Thus:	Against 32° is	2 h.	8 min.	
	" 34′ "		2	16 sec.
	" 45″ "			3
Answer as above,		2 h.	10 m.	19 s.

PROBLEM II.

TO CONVERT TIME INTO DEGREES, ETC.

RULE.—Multiply the hours by 15, and to the product add one fourth of the minutes, seconds, &c., observing that every minute of *time* makes ¼°, and every second of time, ¼′.

EXAMPLE 1.—In 2 hours, 10 minutes, and 19 seconds; how many degrees?

Thus:	2 h.	10 m.	19 sec.
	15		
	30°		
Add 10 quarters, or ¼ of the min.	2	30′	
Add 19 quarters, or ¼ of the sec.		4	45″
Ans.	32°	34′	45″

This problem is readily solved by means of Table IX. without the labor of calculation:

Thus:	2 hours =	30°		
	10 minutes =	2	30′	
	19 seconds =		4	45″
Ans.		32°	34′	45″

Ex. 2.—When it is 12 o'clock at Hartford, it is 4 hours, 51 minutes, and 20 seconds past noon at Greenwich; how many degrees is Hartford west of Greenwich?

Thus: 15 times 4 is 60—added to ¼ of 51, is 72° 45″ and this increased by ¼ of 20, is 72° 50′. Ans.

Ex. 3.—A Liverpool packet, after sailing several days from New York, finds the time by the Sun 2 hours and 40 minutes later than by the ship's chronometer: how far has the ship progressed on her way?

Ex. 4.—A vessel leaves Boston, and having been tossed about in foul weather for some days, finds, that when it is 12 o'clock by the Sun, it is only 11 o'clock and 50 minutes by the watch; is the vessel east or west of Boston; and how many degrees?

Ex. 5.—The moment of greatest darkness during the annular eclipse of 1831, took place at New Haven, 10 minutes after 1 o'clock. A gentleman reports that it happened precisely at 1, where he observed it; and another, that it was 5 minutes after 1 where he saw it: *Quere.* How far east or west were these gentlemen from each other and how many degrees from New Haven?

PROBLEM III.

TO FIND WHAT STARS ARE ON THE MERIDIAN AT NINE O'CLOCK IN THE EVENING OF ANY GIVEN DAY.

Rule.—Look for the given day of the month, at the bottom of the maps, and all the stars having the same degree of right ascension will be on the meridian at that time.

Example 1.—What stars will be on the meridian at 9 o'clock, the 19th of January?

Solution.—On Plate III. I find that the principal stars standing over against the 19th of January, are Rigel and Capella.

Ex. 2.—What stars are on the meridian the 20th of December? Ans. Menkar and Algol.

PROBLEM IV.

ANY STAR BEING GIVEN, TO FIND WHEN IT CULMINATES.

Rule.—Find the star's right ascension in the table, or by the map, (on the equinoctial,) and the day of the month at the top or bottom of the map will be the day on which it culminates at 9 o'clock.

Example 1.—At what time is the bright star Sirius on the meridian?

Solution.—I find by the table, and by the map, that the right ascension of Sirius is 6 hours and about 38 minutes; and the time corresponding to this, at the bottom of the map, is the 11th of February.

Ex. 2.—At what time is Alpheratz, in the head of Andromeda, on the meridian? Ans. The 9th of November.

PROBLEM V.

THE RIGHT ASCENSION AND DECLINATION OF A PLANET BEING GIVEN, TO FIND ITS PLACE ON THE MAP.

Rule.—Find the right ascension and declination of the planet on the map, and that will be its place for the given day.

Example 1.—Venus' right ascension on the 1st of January 1833, was 21 hours, 30 minutes, and her declination 16¾° south; required her situation on the map?

Solution.—On the right hand of the Plate II. I count off 16¾° from the equinoctial, on the marginal scale south, and from that point, 30 minutes to the left, or just half the distance between the XXI. and XXII. meridian of right ascension, and find that Venus, that day, is within two degrees of Delta Capricorni, near the constellation Aquarius, in the zodiac.

Note.—It is to be remembered, that the planets will always be found within the limits of the zodiac, as represented in the maps. By means of Table VII. the pupil can find at any time the situations of all the visible planets, on the maps; and this will enable him to determine their position in the heavens, without a chance of mistake. By this means, too, he can draw for himself the path of the planets from month to month, and trace their course among the stars. This is a pleasant and useful exercise, and is practised extensively in some academies. The pupil draws the map in the first place, or such a portion of it as to include the zodiacal constellations; then, having dotted the position of the planets from day to day, as indicated in Table VII., their path is easily traced with a pen or pencil.

Ex. 2.—Mars' right ascension on the 13th of March, 1833, is 5 hours, 1 minute, and his declination 24¾° north; required his situation on the map?

Solution.—I find the fifth hour line or meridian of right ascension on Plate III., and counting upwards from the equinoctial 24¾°, I find that Mars is between the horns of Taurus, and about 5° S. W. of Beta Aurigæ.

Ex. 3.—Required the position of Jupiter and Saturn on the 13th of February and the 25th of May?

When the right ascension and declination of the planets are not given, they are to be sought in Table VII.

PROBLEM VI.

TO FIND AT WHAT MOMENT ANY STAR WILL PASS THE MERIDIAN ON A GIVEN DAY.

Rule.—Subtract the right ascension of the Sun from the star's right ascension, found in the tables: observing to add 24 hours to the star's right ascension, if less than the Sun's, and the difference will show how many hours the star culminates after the Sun.

Example 1.—At what time will Procyon pass the meridian the 24th of February?

Solution.—R. A. of Procyon 7h. 30m. 33s.+24h.

	31	30′	33″
R. A. of Sun, 24th of Feb.	22	29	1
Ans.	9	1	32

That is, 1m. 32s. past 9 o'clock in the evening.

Ex. 2.—At what time will Denebola pass the meridian on the first of April?

Solution.—R. A. of Denebola is	11h.	40′	32″
R. A. of Sun, April 1,	0	41	25
Ans.	10	59	7

That is, at 59 minutes, 7 seconds, past 10 in the evening.

Ex. 3.—At what time on the first day of each month, from January to July, will Alcyone, or the Pleiades, pass the meridian?

Ex. 4.—At what time will the Dog-Star, or Sirius, culminate on the first day of January, February, and March?

Ex. 5.—How much earlier will Spica Virginis pass the meridian on the 4th of July, than on the 15th of May?—Ans. 3 hours, 25 minutes.

PROBLEM VII.

TO FIND WHAT STARS WILL BE ON OR NEAREST THE MERIDIAN AT ANY GIVEN TIME.

Rule.—Add the given hour to the Sun's right ascension, found in Table III., and the sum will be the right ascension of the meridian, or mid-heaven; and then find in Table II. what star's right ascension corresponds with, or comes nearest to it, and that will be the star required.

Example 1.—What star will be nearest the meridian at 9 o'clock in the evening of the 1st of September?

Solution.—Sun's right ascension 1st September,

	10h	40′	30″
Add the time from noon	9	0	0
Right ascension of the meridian	19h	40′	30″

Now all the stars in the heavens which have this right ascension, will be on the meridian at that time. On looking into Table II. the right ascension of Altair, in the Eagle, will be found to be 19h. 40m.; consequently Altair is on the meridian at the time proposed; and Delta, in the Swan, is less than two minutes past the meridian.

Ex. 2.—Walking out in a bright evening on the 4th of September, I saw a very brilliant star almost directly overhead; I looked on my watch, and it wanted 20 minutes of 8; required the name of the star?

Solution.—Sun's declination 4th of September,

	10h	51′	22″
Add the time from noon	7	40	0
Gives R. A. of Lyra, nearly	18	31	22

Ex. 3.—About 8½ minutes after 8 in the evening of the 11th of February, I observed a bright star on the meridian, a little north of the equinoctial, and 1 minute before 9 a still brighter one, further south; required the names of the stars?

PROBLEM VIII.

TO FIND WHAT STARS WILL CULMINATE AT 9 O'CLOCK IN THE EVENING OF ANY DAY IN THE YEAR.

Rule.—Against the day of the month in Table IV., find the right ascension of the mid-heaven, and all those stars in Table II. which have the same, or nearly the same right ascension, will culminate at 9 P. M. of the given day.

Example 1.—What star will culminate at 9 in the evening of the 26th of March?

Solution.—I find the right ascension of the meridian, at 9 o'clock in the evening of the 26th of March, is 9h 19′ 37″; and on looking into Table II., I find the right ascension of Alphard, in the heart of Hydra, is 9h 19′ 23″. The star is Alphard.

Ex. 2.—What star will culminate at 9 in the evening of the 28th of June? Ans. Aphacca.

PROBLEM IX.

TO FIND THE SUN'S LONGITUDE OR PLACE IN THE ECLIPTIC, ON ANY GIVEN DAY.

Rule.—On the lower scale, at the bottom of the Planisphere, (Plate VIII.) look for the given day of the month; then the sign and degree corresponding to it on the scale immediately above it, will show the Sun's place in the ecliptic.

Example 1.—Required the Sun's longitude, or place in the ecliptic, the 16th of September.

Solution.—Over the given day of the month, September 16th, stands 5 signs and 23 degrees, nearly, which is the Sun's place in the ecliptic at noon on that day; that is, the Sun is about 23 degrees in the sign Virgo.

N. B. If the 5 signs be multiplied by 30, and the 23 degrees be added to it, it will give the longitude in degrees, 173.

Ex. 2.—Required the Sun's place in the ecliptic at noon on the 10th of March.

PROBLEM X.

GIVEN THE SUN'S LONGITUDE, OR PLACE IN THE ECLIPTIC, TO FIND HIS RIGHT ASCENSION AND DECLINATION.

Rule.—Find the Sun's place in the ecliptic, (the curved line which runs through the body of the planisphere,) and with a pair of compasses take the nearest distance between it and the nearest meridian, or hour circle, which being applied to the graduated scales at the top or bottom of the planisphere, (measuring from the same hour circle,) will show the Sun's right ascension. Then take the shortest distance between the Sun's place in the ecliptic and the nearest part of the equinoctial, and apply it to either the east or west marginal scales, and it will give the Sun's declination.

Example 1.—The Sun's longitude, September 16th, 1833, is 5 signs, 23 degrees, nearly; required his right ascension, and declination.

Solution.—The distance between the Sun's place in the ecliptic and the nearest hour circle being taken in the compasses, and applied to either the top or bottom graduated scales, shows the right ascension to be about 11 hours 35 minutes; and the distance between the Sun's place in the ecliptic, and the nearest part of the equinoctial, being applied to either the east or west marginal scales, shows the declination to be about 2° 45′, which is to be called north, because the Sun is to the northward of the equinoctial: hence the Sun's right ascension, on the given day, at noon, is about 11 hours 35 minutes, and his declination 2° 45′ N.

Ex. 2.—The Sun's longitude March 10th, 1833, is 11 signs, 19 degrees, nearly; required his right ascension and declination?

Ans. R. A. 23 h. 21 min. Decl. 4° 11′ nearly.

PROBLEM XI.

TO FIND THE RIGHT ASCENSION OF THE MERIDIAN AT ANY GIVEN TIME.

Rule.—Find the Sun's place in the ecliptic by Problem IX. and his right ascension by Problem X., to the eastward of which, count off the given time from noon, and it will show the right ascension of the meridian, or mid-heaven.

Example 1.—Required the right ascension of the meridian 9 hours, 25 minutes past noon, September 16th, 1833.

Solution.—By Problems IX. and X., the Sun's right ascension at noon of the given day, is 11 hours, 35 minutes; to the eastward of which, 9 hours and 25 minutes (the given time) being counted off, shows the right ascension of the meridian to be about 21 hours.

Ex. 2.—Required the right ascension of the meridian at 6 hours past noon, March 10th, 1833?

Solution.—By Problems IX. and X., the Sun's right ascension at noon of the given day, is 23 hours and 21 minutes; to the eastward of which, the given time, 6 hours, being counted off, shows the right ascension of the meridian to be about 5 hours, 21 minutes.

REMARK.—In this example, it may be necessary to observe, that where the eastern, or left-hand extremity of the planisphere leaves off, the western, or right-hand extremity begins; therefore, in counting off the given time on the top or bottom graduated scales, the reckoning is to be transferred from the left, and completed on the right, as if the two outside edges of the planisphere were joined together.

PROBLEM XII.

TO FIND WHAT STARS WILL BE ON OR NEAR THE MERIDIAN, AT ANY GIVEN TIME.

RULE.—Find the right ascension of the meridian by Problem XI., over which lay a ruler, and draw a pencil line along its edge from the top to the bottom of the planisphere, and it will show all the stars that are on or near the meridian.

EXAMPLE 1.—Required what stars will be on or near the meridian at 9 hours, 25 minutes past noon, Sept. 16th, 1833?

Solution.—The right ascension of the meridian by Problem XI. is 21 hours: this hour circle, or the line which passes up and down through the planisphere, shows that no star will be directly on the meridian at the given time; but that Alderamin will be a little to the east, and Deneb Cygni a little to the west of it; also Zeta Cygni, and Gamma and Alpha in the Little Horse, very near it on the east.

PROBLEM XIII.

TO FIND THE EARTH'S MEAN DISTANCE FROM THE SUN.

RULE.—As the Sun's horizontal parallax is to radius, so is the semi-diameter of the Earth to its distance from the Sun.

By Logarithms.—As tangent of the Sun's horizontal parallax is to radius, so is the Earth's semi-diameter to her mean distance from the Sun.

8″.5776 : 206264″.8 : : 3962 : 95,273,869 miles.

By Logarithms.

As tangent of the Sun's horizontal parallax,	8''.5776	=	5.6189407
Is to radius, or 90°,		=	10.0000000
So is the Earth's semi-diameter,	3962.	=	3.5979143
To the Earth's distance,	95,273,869	=	7.9789733

PROBLEM XIV.

TO FIND THE DISTANCE OF ANY PLANET FROM THE SUN, THAT OF THE EARTH BEING KNOWN.

RULE.—Divide the square of the planet's sidereal revolution round the Sun, by the square of the Earth's sidereal revolution, and multiply the cube root of the quotient by the Earth's mean distance from the Sun.

By Logarithms.—From twice the logarithm of the planet's sidereal revolution, subtract twice the logarithm of the Earth's sidereal revolution, and to one third of the remainder, add the logarithm of the Earth's mean distance from the Sun.

EXAMPLE.—Required Mercury's mean distance from the Sun, that of the Earth being 95,273,869 miles.

Mercury's sidereal revolution is 87.969258 days, or 7600543''.8912: the Earth's sidereal revolution is 365.256374417 days, or

31558151''.5	7600543 .9
31558151''.5	7600543 .9
995916962096952.25 by which divide	57768267575827 .21

and the quotient will be 0 .052005106713292, the cube root of which is 0.3870977, and this multiplied by 94,881,891, gives 36,727,607 miles, for Mercury's distance from the Sun. This problem may be performed by logarithms in as many *minutes* as the former method requires *hours*.

Mercury's Sid. Rev. 7600543''.9 log. = 6.8808447×2	13.7616894
Earth's Sid. Rev. 31558151''. log. = 7.4991302×2	14.9982604
	⅓)—2.7634290
	1.5878097
Add. log. of the Earth's mean distance,	7.9789733
	7.5667835

Mercury's distance, 36,880,422. Ans.

If the pupil have not already learned the use of logarithms, this problem will satisfy him of their unspeakable advantage over all other modes of computation. By reviewing the above calculation, he will perceive that instead of multiplying 31558151' .5 by itself, he need only multiply its logarithms by *two!* and instead of extracting the cube root of 0.05800510671 3292, he need only divide its logarithm by *three!* and instead of multiplying 0.3870977, by 95,273,869, he need only *add* their logarithms together. He need not think himself a *dull* scholar, if by the former method he come to the true result in *five hours;* nor remarkably quick, if by the latter he come to it in *five minutes.*

PROBLEM XV.

TO FIND THE HOURLY MOTION OF A PLANET IN ITS ORBIT.

RULE.—Multiply the planet's mean distance from the Sun by 6.2831853, and divide the product by the time of the planet's sidereal revolution, expressed in hours, and the decimals of an hour.

By Logarithms.—Add 0.7981799 to the logarithm of the planet's mean distance from the Sun, and from the sum subtract the logarithm of the planet's revolution expressed in hours.

EXAMPLE.—Required the Earth's hourly motion in its orbit.

Log. of Earth's distance = 7.9789733 + 0.7981799 =	8.7771537
Subtract log. of Earth's revolution	3.9428090
Gives Earth's horary motion, 68,288 miles,	4.8343447

PROBLEM XVI.

TO FIND THE HOURLY MOTION OF A PLANET ON ITS AXIS.

RULE.—Multiply the diameter of the given planet by 3.14159, and divide the product by the period of its diurnal rotation.

By Logarithms.—Add 4.0534524 to the logarithm of the planet's diameter, and from the sum subtract the logarithm of its diurnal rotation, expressed in seconds.

Earth's diameter. 7924 log. =	3.8989445
Add log. of 3600″ + log. of 3.14159 =	4.0534524
	7.9523969
Subtract log. diurnal rotation, 23h. 56′ 4″.09 =	4.9353263
Ans. 1040.09 miles =	3.0170706

PROBLEM XVII.

TO FIND THE RELATIVE MAGNITUDE OF THE PLANETS.

RULE.—Divide the cube of the diameter of the larger planet by the cube of the diameter of the less.

By Logarithms.—From three times the logarithm of the larger, subtract three times the logarithm of the less.

EXAMPLE.—How much does the size of the Earth exceed that of the Moon?

Earth's diameter, 7912 log. 3.8982863 × 3 =	11.6948589
Moon's diameter. 2160 log. 3.3343376 × 3 =	10.0030128
The Earth exceeds the Moon, 49.1865 times. Ans.	1.6918461

In this example. 7912 miles is assumed as the *mean* between the Earth's equatorial and polar diameter: the former being 7924, and the latter 7898 miles.

PROBLEM XVIII.

TO FIND THE PROPORTION OF SOLAR LIGHT AND HEAT AT EACH OF THE PLANETS.

RULE.—Divide the square of the planet's greater distance from the Sun, by the square of the less.—Or, subtract twice the logarithm of the greater distance from twice the logarithm of the less.

Example.—How much greater is the Sun's light and heat at Mercury, than at the Earth?

Log. of Earth's distance	7.9789738 × 2 = 15.9579476
— of Mercury's	7.5667959 × 2 = 15.1335918
Ans. 6.6736 times greater =	0.8243558

PROBLEM XIX.

TO FIND THE CIRCUMFERENCE OF THE PLANETS.

Rule.—Multiply the diameter of the planet by 3.14159, or, add the logarithm of the planet's diameter to 0.4971499.

PROBLEM XX.

TO FIND THE CIRCUMFERENCE OF THE PLANETARY ORBITS.

Rule.—Multiply the planet's mean distance from the Sun by 6.2831853; or, to the logarithm of the planet's mean distance, add 0.7981799, and the sum will be the logarithm of the answer.

PROBLEM XXI.

TO FIND IN WHAT TIME ANY OF THE PLANETS WOULD FALL TO THE SUN, IF LEFT TO THE FORCE OF GRAVITATION ALONE.

Rule.—Multiply the time of the planet's sidereal revolution, by 0.176776; the result will be the answer.

By Logarithms.—From the logarithm of the planet's sidereal revolution, subtract 0.7525750, and the remainder will be the logarithm of the answer, in the same denomination as the sidereal revolution.

Required the times, respectively, in which the several planets would fall to the Sun by the force of gravity.

Planets would fall to the Sun.	Days.	H.	M.	S.	Logarithms.
Mercury,	15	13	13	16	6.1282686
Venus,	39	17	19	22	6.5355424
Earth,	64	13	38	55	6.7465357
Mars,	121	10	36	3	7.0208817
Jupiter,	765	21	33	35	7.8206849
Saturn,	1901	23	24	4	8.2157186
Herschel.	5424	16	52	1	8.6708897
Moon to the Earth,	4	19	54	57	5.6204459

Tabular Elements of the Solar System.

Names of the Planets.	Sidereal Revolutions in Mean Solar Days.	Logarithms.	True mean distances from the Sun in miles.	Logarithms of Planets' distances.	Relative distances.	Logarithms.
Mercury,	87 9692580	1.944330,930294	36,880,422.34907587	7.566795,885867	0.387099031323	1.587822,083445
Venus,	224.7007869	2.351604 479472	68,914,654.84245489	7.838311,585319	0.723332175563	1.859337,782897
Earth,	365.2563744	2.562597,805126	95,273 868.86774855	7.978973,802422	1.000000000000	0.090000,000000
Mars,	686.9796458	2.836943,867587	145,168,094.89281471	8.161871,177396	1.523692662196	0.182897,374974
Vesta,	1325.7431000	8.122459,408208	225,016,762.14714600	8.352214,871143	2.361788860064	0.373241,068721
Juno,	1592.6608000	3.202123,345262	254,287,002.55155636	8.405324,162513	2.669010984581	0.426350,360091
Ceres,	1681.3931000	3.225669,267668	263,646,156.30912176	7.421021,444117	2.767245199994	0.442047,641698
Pallas,	1686.5388000	3 226996 342519	264.183,786.59075400	8.421906,160684	2.772888198314	0.442932,358262
Jupiter,	4332.5848212	3.636747,074052	495 533,836.87042950	8.695073,315039	5.201151614387	0.716099,512617
Saturn,	10759.2198174	4 031780,779676	908,717,975.06526816	8.958429,118755	9.537956061453	0.979455,316333
Herschel,	30686.8208296	4.486951,895561	1827,580,558 25499525	9.261876,529379	19.182390512469	1.282902,726957

Names of the Planets, &c.	Diameters at the Earth's M. Dist.	Relative Diameters.	True Diameters in miles.	Comparative Volumes.	Hourly Motion, in miles.	Comparative Light and Heat.
Sun, . . .	32′ 1″.8000	112.02434	887,681	1405814.16195		
Mercury, . . .	6.4600	.37656	2,984	.05339	109,757	6.67363
Venus, ...	16.5000	.96181	7,621	.88974	80,293	1.91128
Earth, ...	17.1552	1.00000	7,924	1.00000	68,288	1.00000
Mars, ...	8.1400	.53278	4,222	.15123	55,322	—2.32164
Vesta, ...	.5824	.03395	,269	00004	44,435	—5.57805
Juno, ...	1.0158	.17580	1,393	.00543	41,799	—7.12362
Ceres, ...	3.4250	.19664	1,582	.00796	41,051	—7 65764
Pallas, ...	4.8740	.25429	2,025	.01669	41,009	—7.86800
Jupiter, ...	3 6.7400	10.88530	86.255	1289.81000	29,943	—27.05197
Saturn, ...	2 57.4400	10.34320	81,954	1160.54000	22,111	—90.97260
Herschel, . . .	1 14.4000	4.33688	34,265	81.57020	15,592	—367.97400

TABLE I.

Containing the names of the Constellations, the number and magnitude of the Stars in each, and the days on which they come to the meridian at 9 o'clock in the evening.

Number.	Month.	Day.	Constellations.	R. A.	Declination.		No. of Stars.	Magnitudes.					
								1	2	3	4	5	6
1	Jan	4	Eridanus,	60°	10°	S.	84	1	1	11	27	20	57
2		6	Reticulus,	62	62	S.	10	0	0	2	3	2	5
3		9	Taurus,	65	16	N.	141	1	1	4	8	23	60
4		11	Brandenburgh Sceptre,	67	15	S.	3						
5		12	Praxiteles,	68	40	S.	16	0	0	0	0	4	18
6		12	Camelopard,	68	70	N.	58	0	0	0	6	25	42
7		18	Auriga,	75	45	N.	66	1	1	0	9	20	26
8		18	Sword Fish,	75	62	S.	6	0	0	1	1	4	24
9		19	Mons Mensæ,	76	72	S.	30	0	0	0	0	0	30
10		23	Lepus, the Hare,	80	18	S.	19	0	0	3	7	3	13
11		23	Orion,	80	0		78	2	4	3	15	18	36
12		26	Painter's Horse,	84	55	S.	8	0	0	0	1	0	39
13		27	Noah's Dove,	85	35	S.	10	0	1	1	2	4	53
14	Feb.	16	Canis Major,	105	20	S.	31	1	4	2	7	7	36
15		22	Monoceros,	110	0		31	0	0	0	7	7	12
16		23	Gemini,	111	32	N.	85	0	2	3	6	13	27
17		23	The Lynx,	111	50	N.	44	0	0	0	3	15	25
18		27	Argo Navis,	115	50	S.	64	2	4	9	12	37	289
19	March.	4	Canis Minor,	112	5	N.	14	1	0	1	0	3	9
20		12	Flying Fish,	127	68	S.	8	0	0	0	0	6	8
21		13	Cancer,	126	20	N.	83	0	0	0	3	8	11
22		15	Mariner's Compass,	130	30	S.	4	0	0	0	0	2	13
23		25	Hydra,	139	8	S.	60	0	1	0	13	16	43
24	April.	1	Sextans,	150	0		41	0	0	0	1	6	36
25		6	Leo Minor,	150	35	N.	53	0	0	1	5	10	39
26		6	Leo Major,	150	15	N.	95	1	1	6	15	12	47
27		6	Air Pump,	150	32	S.	3	0	0	0	0	2	15
28		9	Ursa Major,	153	60	N.	87	1	3	7	13	31	37
29		16	Robur Carroli,	159	50	S.	12						
33		26	Crater, the Cup,	168	15	S.	31	0	0	0	10	9	14
34	May.	3	Chameleon,	175	78	S.	10	0	0	0	0	6	35
35		11	The Cross,	185	60	S.	5	1	2	1	1	1	12
36		13	Coma Berenices,	185	26	N.	43	0	0	0	13	13	17
37		13	Corvus, the Crow,	185	15	S.	9	0	0	3	2	2	2
38		13	Southern Fly,	185	68	S.	5	0	0	0	4	0	17
39		19	Cor Caroli,	191	39	N.	3						
40		23	Virgo,	195	5	N.	110	1	0	6	10	16	71
41		28	Asterion et Chara,	200	40	N.	25	0	0	1	1	7	15
		28	Centaurus,	200	50	S.	35	2	1	6	10	14	100
42	June.	9	Bootes,	212	20	N.	54	1	0	7	10	18	30
43		19	Compasses,	222	64	S.	4	0	0	0	1	1	8
44		21	Mons Mænalus,	225	5	N.	11						
45		22	Libra,	226	8	S.	51	0	2	3	12	4	27
46		26	Lupus, the Wolf,	230	45	S.	24	0	0	3	3	18	29
47	July.	1	Corona Borealis	235	30	N.	21	0	1	1	5	9	5
48		1	Ursa Minor,	235	75	N.	24	0	1	2	4	6	4

TABLE I.—Continued.

Number.	Month	Day	Constellations.	R. A.	Declination.	No. of Stars.	Magnitudes. 1	2	3	4:	5	6
49	July.	1	The Serpent,	235°	10° N.	64	0	1	9	5	3	40
50		4	S. Triangle,	238	65 S.	5	0	1	2	0	1	16
51		8	Euclid's Square,	242	45 S.	12	0	0	0	.0	3	26
52		10	Scorpio,	244	26 S.	44	1	1	11	10	4	29
53		18	Bird of Paradise,	252	75 S.	11	0	0	0	0	2	16
54		21	Ara, the Altar,	255	55 S.	9	0	0	3	3	1	30
55		21	Hercules,	255	22 N.	113	0	1	8	19	36	46
56		26	Serpentarius.	260	13 N.	74	0	1	5	10	9	42
57	August.	5	Draco,	270	66 N.	80	0	4	7	12	25	32
58		6	Cerberus,	271	22 N.							
59		10	Scutum Sobieski,	275	10 S.							
60		10	Taurus Poniatowski,	275	7 N.	16	0	0	0	3	1	12
61		13	Corona Australis,	278	40 S.	12	0	0	0	0	5	10
62		13	Telescopium,	278	40 S.	9	0	0	0	3	6	30
63		19	Lyra, the Harp,	283	38 N.	21	1	0	2	2	6	12
64		21	Sagittarius,	285	33 S.	69	0	0	5	10	12	59
65		29	Antinous,	292	0							
66	Sept.	1	Sagitta,	295	18 N.	18	0	0	0	4	0	15
67		1	Aquila,	295	8 N.	71	1	0	9	7	14	38
68		6	Fox and Goose,	300	25 N.	35	0	0	0	5	13	21
69		9	The Peacock,	302	68 S.	14	0	1	2	3	4	80
70		15	Delphinus,	308	15 N.	18	0	0	5	1	2	11
71		18	Cygnus,	308	42 N.	81	0	1	6	11	16	49
72		18	Capricorn,	310	20 S.	51	0	0	3	3	7	4
73		18	Hadley's Quadrant	310	80 S.	43	0	0	1	0	6	64
74		23	Microscopium,	315	35 S.	10	0	0	0	0	1	12
75		23	The Indian,	315	55 S.	12	0	0	1	1	2	54
76		24	Equulus,	316	5 N.	10	0	0	0	4	1	5
77	Oct.	10	The Crane,	330	45 S.	13	0	1	2	2	6	41
78		15	Aquarius,	335	14 S.	108	0	0	4	7	28	59
79		15	Southern Fish,	335	30 S.	24	1	0	2	5	9	19
80		16	The Lizard,	336	43 N.	16	0	0	0	3	7	7
81		18	Cepheus,	338	68 N.							
82		20	Pegasus,	340	14 N.	89	0	3	3	9	14	51
83	Nov.	9	American Goose,	359	66 S.	.9	0	0	1	2	5	58
84		13	Officina Sculptoria.	3	38 S.	12	0	0	0	0	5	29
85		15	Pisces,	5	10 N.	113	0	0	13	5	28	63
86		20	Phœnix,	10	50 S.	13	0	1	1	3	7	63
87		22	Cassiopeia,	12	60 N.	55	0	0	5	6	8	38
88		23	Andromeda,	14	30 N.	66	0	3	2	12	15	34
89	Dec.	4	Cetus,	25	12 S.	97	0	2	9	10	11	66
90		6	Triangulum,	27	32 N.	16	0	0	0	3	1	7
91		6	Hydrus,	28	66 S.	10	0	0	2	3	2	38
92			Aries,	30	22 N.	66	0	1	1	2	6	22
93		10	Triangulum Min.	22	28 N.	5						
94		17	Horologium,	40	55 S.	12	0	0	0	0	2	39
95		17	Musca,	42	28 N.	4	0	0	1	2	1	
96		19	Chemical Furnace,	44	30 S.	14	0	0	0	0	2	43
97		21	Caput Medusæ,	44	40 N.							
98		23	Perseus,	46	49 N.	59	0	2	4	10	14	31

TABLE II.

Exhibiting the Right Ascension and Declination of the principa
Fixed Stars, and the time of their coming to the Meridian.

Those to which S is annexed are in South declination; the others are in North declination.

No.	Names of the Stars.	Mag.	Right Ascension. H.	M.	S.	Declination. °	′	″	On the Merid.	Day.
1	ε Persei,	3	3	47	8	39	31	37	Jan.	1
2	γ Eridani,	3	3	50	15	13	59	4S.		2
3	ο Eridani,	3	4	3	31	7	16	32S.		5
4	ε Tauri,	3	4	18	52	18	8	18		8
5	α Tauri, Aldebaran,	1	4	26	21	16	10	4		10
6	β Eridani,	3	4	39	35	5	18	0S.		13
7	α Aurigæ, Capella,	1	5	4	22	45	49	10		19
8	β Orionis, Rigel,	1	5	6	31	8	23	55S.		20
9	β Tauri, El Nath,	2	5	15	44	28	27	39		22
10	η Orionis,	3	5	15	36	2	33	17S.		22
11	γ Orionis, Bellatrix,	2	5	16	11	6	11	32		22
12	β Leporis, Nibal,	3	5	21	22	20	53	46S.		23
13	δ Orionis, Mintaka,	2	5	23	29	0	25	39S.		24
14	α Leporis, Arneb,	3	5	25	33	17	56	50S.		24
15	ε Orionis, Anilam,	2	5	27	44	1	18	49S.		25
16	ζ Tauri,	3	5	27	53	21	2	7		25
17	ζ Orionis, Alnitak,	2	5	32	20	2	2	9S.		26
18	α Columbæ, Phaet,	2	5	33	9	34	10	2S.		26
19	χ Orionis, Saiph,	3	5	39	29	9	44	2S.		27
20	β Columbæ,	3	5	45	6	35	50	12S.		29
21	α Orionis, Betelguese	1	5	46	8	7	22	6		29
22	ββAurigæ, Menkalina	2	5	47	17	44	55	24		29
23	η Geminorum, Tejat,	3.4	6	4	54	22	23	1	Feb.	3
24	μ Geminorum,	3	6	12	54	22	35	48		4
25	ζ Canis Majoris,	3	6	14	4	29	59	36S.		5
26	β Ca. Maj., Mirzam,	2	6	15	23	17	52	41S.		5
27	α Navis, Canopus,	1	6	20	15	52	36	23S.		6
28	γ Gemino., Alhena,	3	6	28	4	16	32	18		8
29	α Canis Maj., Sirius,	1	6	37	47	16	29	27S.		11
30	ε Canis Maj., Adhara,	3	6	53	14	28	44	55S.		15
31	ζ Geminorum.	3	6	53	53	20	48	36		15
32	γ C. Maj., Muliphen,	3	6	56	26	15	23	20S.		16
33	δ C. Majoris, Wesen,	3	7	1	17	26	7	53S.		17
34	δ Gemino., Wasat,	3	7	10	8	22	17	6		19
35	π Argo Navis,	3	7	11	7	36	48	7S.		19
36	η C. Maj., Aludra,	3	7	17	16	28	58	50S.		21
37	α Gemino., Castor,	2	7	23	56	32	14	52		23
38	α C. Minor, Procyon,	1	7	30	33	5	38	55		24
39	γ Ar. Navis, Markab,	3	7	32	17	26	26	22S.		25
40	β Gemino., Pollux,	2	7	35	5	28	25	28		26

TABLE II.—Continued.

No.	Names of the Stars.	Mag.	Right Ascension.			Declination.			On the Merid.	Day.
			H.	M.	S.	°	′	″		
41	ξ Argo Navis,	3	7	42	20	24	26	35S.	Feb.	28
42	ζ Argo Navis, Naos.	2	7	57	44	39	32	3S.	Mar.	4
43	γ Argo Navis,	2	8	4	23	46	50	43S.		5
44	ε Argo Navis,	2.3	8	19	5	58	58	33S.		9
45	δ Argo Navis,	2.3	8	40	7	54	5	43S.		15
46	ι Ursæ Majoris,	3	8	47	47	48	41	50		17
47	α Cancri, Acubens,	3.4	8	49	45	12	30	9		18
48	λ Argo Navis,	2.3	9	1	51	42	45	40S.		21
49	β A. N., Maia Placid.	1	9	12	57	69	1	54S.		24
50	χ Argo Navis,	2.3	9	16	59	54	17	53S.		25
51	α Hydræ, Alphard,	2	9	19	23	7	56	14S.		26
52	θ Ursæ Majoris,	3	9	21	47	53	26	45		27
53	ε Leonis,	3	9	36	22	24	32	26		31
54	μ Leonis, Rasal Asad.	3	9	42	56	26	47	32	April.	1
55	η Leonis,	3.4	9	58	13	17	34	34		6
56	α Leonis Regulus,	1	9	59	28	12	46	52		6
57	λ Ursæ Majoris,	3	10	6	58	43	44	49		8
58	ζ Leonis, Aldhafara,	3	10	7	23	24	14	53		8
59	γ Leonis, Al G'eba,	2.3	10	10	45	20	41	16		9
60	μ U. M., F' Phekrah,	3	10	11	55	42	20	15		9
61	α Leonis Minoris,	3	10	28	47	32	50	39		14
62	θ Argo Navis,	2.3	10	37	12	63	31	14S.		16
63	η Argo Navis,	2	10	38	36	58	48	34S.		17
64	α Crateris, Alkes,	3.4	10	51	35	17	24	36S.		20
65	β Ursæ Maj., Merak,	2	10	51	42	57	16	35		20
66	α Ursæ Maj., Dubhe,	2	10	53	21	62	39	3		21
67	δ Leonis, Zozma,	3	11	5	13	21	27	32		24
68	θ Leonis,	3	11	5	39	16	20	39		24
69	λ Draconis, Giansar,	3	11	20	17	70	15	3		28
70	β Leonis, Denebola,	2	11	40	32	15	30	22	May.	3
71	β Virginis, Zavijava,	3	11	42	0	2	42	43		3
72	γ U. Maj., Phach'd,	2	11	45	1	54	37	25		4
73	δ Centauri,	2.3	11	59	44	49	30	15S.		8
74	δ Crucis,	3	12	6	21	57	32	4S.		10
75	δ Ursæ M., Megrez.,	3	12	7	7	57	58	46		10
76	γ Corvi,	3	12	7	38	16	36	42S.		10
77	α Crucis,	1	12	17	23	62	10	26S.		13
78	δ Corvi, Algorab,	3	12	21	38	15	34	49S.		14
79	γ Crucis,	2	12	21	56	56	10	22S.		14
80	β Corvi,	3	12	25	39	22	28	9S.		15

TABLE II.—Continued.

No.	Names of the Stars.	Mag.	Right Ascension.			Declination.			On the Merid.	Day.
			H.	M.	S.	°	′	″		
81	χ Draconis,	3	12	26	23	70	42	38	May.	15
82	γ Centauri,	2.3	12	32	23	48	2	23S.		16
83	γ Virginis,	3	12	33	37	0	31	55S.		17
84	β Crucis,	2	12	38	3	58	46	27S.		18
85	ε Ur. Majoris, Alioth,	2	12	46	27	57	52	5		20
86	δ Virginis,	3	12	47	12	4	18	31		20
87	α Cor-Caroli,	3	12	47	57	39	13	21		20
88	ε Vir., Vindemiatrix,	3	12	56	36	11	51	32		22
89	γ Hydræ,	3	13	9	42	22	17	9S.		26
90	ι Centauri,	3	13	10	48	35	49	49S.		26
91	α Virginis, Spica,	1	13	16	24	10	17	10S.		27
92	ζ Ursæ Maj., Mizar,	2	13	17	11	55	17	59		28
93	ζ Virginis,	3	13	25	36	0	15	43		30
94	ε Centauri,	2.3	13	29	20	52	32	20S.		31
95	η U. M., Benetnasch,	2	13	40	57	50	8	58	June.	2
96	ζ Centauri,	3	13	45	11	46	27	37S.		3
97	η Bootis,	3	13	46	32	19	14	39		4
98	β Centauri,	1.2	13	52	8	59	33	36S.		5
99	α Draconis, Thuban,	3	13	59	52	65	10	31		7
100	α Bootis, Arcturus,	1	14	8	3	20	3	21		8
101	η Centauri,	2.3	14	24	54	41	25	0S.		13
102	γ Bootis, Seginus,	3	14	25	17	39	2	32		13
103	α Centauri,	1.2	14	28	58	60	9	28S.		14
104	α Lupi,	3	14	30	46	46	39	47S.		14
105	ε Bootis, Mirac,	3	14	37	41	27	47	2		16
106	α Libræ, Zubenesch,	2.3	14	41	27	15	20	29S.		17
107	β U. Mino., Kochah,	3	14	51	16	74	50	17		19
108	β Bootis, Nekkar,	3	14	55	12	41	3	18		20
109	β Libræ, Zubenelg,	2.3	15	8	2	8	45	41S.		23
110	δ Serpentis,	3	15	26	32	11	6	14		28
111	α C. Bor., Alphacca,	2	15	27	37	27	16	55		28
112	ι Serpentis, Unuk,	2	15	36	3	6	57	24		30
113	β Serpentis,	3	15	38	29	16	57	7	July.	1
114	ε Serpentis,	3	15	42	36	6	59	7		2
115	γ Serpentis,	3	15	48	26	16	12	59		3
116	π Scorpii,	3	15	48	4	25	37	11S.		3
117	δ Scorpii,	3	15	50	28	22	8	18S.		4
118	β Scorpii,	2	15	55	44	19	20	28S.		5
119	θ Draconis,	3	15	58	37	59	0	32		6

TABLE II.—Continued

No.	Names of the Stars.	Mag.	Right Ascension. H.	M.	S.	Declination. °	′	″	On the Merid.	Day.
120	δ Ophiu., Yed, or Jed.	3	16	5	36	3	15	18S.	July.	7
121	ε Ophiuchi,	3	16	9	39	4	16	37S.		8
122	γ Hercules,	3	16	14	23	19	33	1		9
123	α Scorpii, Antares,	1	16	19	10	26	3	7S.		11
124	η Draconis,	3	16	24	12	61	53	38		11
125	β Hercules, Rutilicus,	3	16	23	22	21	57	36		12
126	ζ Ophiuchi,	3	16	27	45	10	13	15S.		13
127	α Triang. Australis,	2.3	16	31	3	68	42	23S.		14
128	ζ Herculis,	3	16	34	59	31	54	39		15
129	ε Scorpii,	3	16	39	4	33	58	40S.		16
130	μ 1 Scorpii,	3	16	40	8	37	45	14S.		16
131	ζ Scorpii,	3	16	42	52	41	3	33S.		17
132	ε Herculis,	3	16	54	14	31	10	40		19
133	η Ophiuchi,	2.3	17	0	50	15	30	35S.		21
134	α Her., Ras Algethi,	2.3	17	7	2	14	35	17		23
135	δ Herculis,	3	17	8	20	25	2	43		23
136	ζ Draconis,	3	17	8	23	65	55	12		23
137	α Aræ,	3	17	18	57	49	43	54S.		24
138	γ Scorpii, Lesath,	2.3	17	22	58	36	58	24S.		27
139	θ Scorpii,	3	17	25	20	42	52	55S.		27
140	α Ophiu., Ras Alhag.	2	17	28	11	12	41	20		28
141	β Ophiuchi, Cheleb,	3	17	35	36	4	38	40		30
142	γ Ophiuchi,	3	17	39	56	2	46	42		31
143	γ Draconis, Rastaben,	2.3	17	52	44	51	30	42	Aug.	3
144	γ 2 Sagittarii,	3	17	55	5	30	24	40S.		4
145	δ Sagittarii,	3	18	10	1	29	53	28S.		8
146	ε Sagittarii,	2.3	18	12	48	34	27	14S.		8
147	α Lyræ, Vega,	1	18	26	11	38	38	0		12
148	δ Ursæ Minoris,	3	18	28	6	86	35	47		12
149	β Lyræ,	2.3	18	43	55	33	10	33		17
150	σ Sagittarii,	2	18	44	58	26	29	42S.		17
151	θ Serpentis, Alga,	3	18	47	36	3	59	20		18
152	δ Lyræ,	3	18	49	6	36	41	28		18
153	ζ Sagittarii,	3	18	52	1	30	6	40S.		19
154	γ Lyræ, Jugum.,	3	18	52	11	32	27	47		19
155	ε Aquilæ,	3	18	52	26	14	50	4		19
156	ζ A., Deneb e Okab,	3	18	57	44	13	37	20		20
157	π Sagittarii,	3	18	59	54	21	16	56S.		21
158	α Sagittarii,	3.4	19	12	19	40	55	9S.		24
159	δ Draconis,	3	19	12	29	67	21	59		24

TABLE II.—Continued.

No.	Names of the Stars.	Mag.	Right Ascension.			Declination.			On the Merid.	Day.
			H.	M.	S	°	′	″		
160	δ Aquilæ,	3	19	17	5	2	46	57	Aug.	26
161	δ Vulpeculæ,	3.4	19	21	20	24	20	5		27
162	β Cygni, Albireo,	3	19	24	17	27	36	51		28
163	γ Aquilæ, Tarazed,	3	19	38	19	10	12	48		31
164	δ Cygni,	3	19	40	0	44	43	25	Sept.	1
165	α Aquilæ, Altair,	1.2	19	42	38	8	26	2		1
166	β Aquilæ, Alshain,	3	19	47	7	5	59	47		3
167	θ Aquilæ,	3	20	2	38	1	18	39S.		7
168	α 1 Capri., Dshabeh,	3	20	8	23	13	1	59S.		9
169	α 2 Capricorni,	3	20	8	47	13	3	16S.		9
170	β Capricorni, Dabih,	3	20	11	48	15	18	15S.		10
171	α Pavonis,	1.2	20	12	23	57	15	42S.		10
172	γ Cygni, Sa'dr,	3	20	16	11	39	43	32		11
173	ε Delphini,	3	20	25	32	10	44	29		13
174	β Delphini, Rotanen,	3	20	29	29	13	59	53		15
175	α Delphini, Scalovin,	3	20	31	53	15	59	32		15
176	δ Delphini,	3	20	35	29	14	28	53		16
177	α Cygni, Deneb,	1.2	20	35	45	44	41	15		16
178	γ Delphini,	3	20	38	29	15	31	47		17
179	ε Cygni, Gienah,	3	20	39	16	33	20	16		17
180	ζ Cygni,	3	21	5	22	29	32	45		25
181	α Cephei, Alderamin,	3	21	14	35	61	52	45		27
182	β Aquarii,	3	21	22	46	6	18	9S.		29
183	β Cephei, Alphirk,	3	21	26	28	69	49	43	Oct.	2
184	γ Capricorni,	3	21	30	45	17	24	48S.		3
185	ε Pegasi, Enif,	2.3	21	35	32	9	6	47		4
186	δ Capricorni,	3	21	37	49	16	52	33S.		9
187	α Aquarii,	3	21	57	12	1	7	33S.		9
188	α Gruis,	2	21	57	40	47	45	38S.		11
189	ζ Cephei,	3	22	5	5	57	22	59		13
190	γ Aquarii,	3	22	12	38	2	13	40S.		16
191	β Piscis Australis,	3	22	21	50	33	11	44S.		18
192	ε Piscis Australis,	3	22	31	49	27	54	48S.		19
193	ζ Pegasi,	3	22	33	36	9	57	49		22
194	δ Aquarii, Scheat,	3	22	45	43	26	42	31S.		23
195	α Pisc. Aust.,Fomalh.	1	22	48	24	30	30	18S.		24
196	β Pegasi, Scheat,	2	22	55	32	27	10	27		25
197	α Pegasi, Markab,	2	23	56	27	14	18	37	Nov.	3

TABLE II.—Continued.

No.	Names of the Stars.	Mag.	Right Ascension.			Declination.			On the Merid.	Day.
			H.	M	S.	°	′	″		
198	γ Cephei, Er Rai,	3	23	32	16	76	41	52	Nov.	10
199	α Andromedæ, Alph.,	2	23	59	46	28	10	9		10
200	β Cassiopeiæ, Chaph,	3	24	0	36	58	13	47		11
201	γ Pegasi, Algenib,	3	0	4	39	14	15	22		14
202	β Hydrus,	3	0	15	56	78	12	7S.		14
203	α Phœnicis,	2.3	0	18	1	43	12	12S.		17
204	δ Andromedæ,	3	0	30	36	29	56	0		17
205	α Cassiop., Schedir,	3	0	31	5	55	37	13		18
206	β Ceti, Deneb Kaitos,	3	0	35	12	18	54	17S.		21
207	γ Cassiopeia,	3	0	46	41	59	48	41		24
208	α U. M. Alruccabah,	2.3	1	0	19	88	25	7		24
209	β Andro., Mirach,	2	1	0	45	34	44	10		28
210	δ Cassio., Ruchbah,	3	1	14	57	59	21	54	Dec.	2
211	α Eradani, Achernar,	1	1	31	21	58	12	37S.		4
212	ε Cassiopeiæ,	3	1	42	11	62	50	42		4
213	ζ Ceti, Baton Kaitos,	3	1	43	35	11	9	36S.		5
214	β Arietis,	3	1	45	45	20	59	30		7
215	α Piscium, El Rischa,	3	1	53	38	1	57	19		7
216	γ Andro., Almaach,	2	1	53	54	41	31	32		8
217	α Arietis, or El Nath,	2	1	57	47	22	40	11		11
218	ο Ceti, Mira,	3	2	10	36	3	43	59S.		15
219	δ Ceti,	3	2	30	38	0	23	15S.		15
220	ε Ceti,	3	2	31	31	12	34	49S.		16
221	γ Ceti,	3	2	34	38	2	31	57		20
222	γ Persei,	3	2	52	13	52	50	46		20
223	α Ceti, Menkar,	2	2	53	33	3	25	54		21
224	β Persei, Algol,	var.	2	56	52	40	18	30		23
225	α Fornax Chemica,	3	3	5	20	29	39	50S.		23
226	ζ Eridani,	3	3	7	31	9	26	31S.		25
227	α Persei, Algeneb,	2	3	12	26	49	15	38		27
228	ε Eridani,	3	3	25	32	10	1	26S.		29
229	δ Persei,	3	3	31	4	47	14	54		30
230	δ Eridani,	3	3	35	31	10	20	16S.		30
231	η Pleiades, Alcyone,	3	3	37	34	23	35	4		
232	ζ Persei,	3	3	44	0	31	23	26	Jan.	1

TABLE III.

Exhibiting the Sun's Right Ascension, in Time, for every day in the year.

Day.	January.			February.			March.			April.			May.			June.			Day.
	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.	
1	18	46	21	20	58	43	22	47	51	0	41	25	2	32	36	4	35	4	1
2	18	50	46	21	2	47	22	51	35	0	45	3	2	36	25	4	39	19	2
3	18	55	11	21	6	50	22	55	19	0	48	42	2	40	14	4	43	25	3
4	18	59	35	21	10	53	22	59	3	0	52	20	2	44	4	4	47	31	4
5	19	3	59	21	14	54	23	2	46	0	55	59	2	47	55	4	51	38	5
6	19	8	22	21	18	55	23	6	28	0	59	57	2	51	46	4	55	45	6
7	19	12	45	21	22	55	23	10	10	1	3	16	2	55	37	4	59	52	7
8	19	17	7	21	26	54	23	13	52	1	6	56	2	59	30	5	3	59	8
9	19	21	29	21	30	53	23	17	33	1	10	35	3	3	22	5	8	7	9
10	19	25	50	21	34	50	23	21	14	1	14	15	3	7	16	5	12	15	10
11	19	30	11	21	38	47	23	24	54	1	17	55	3	11	10	5	16	24	11
12	19	34	31	21	42	43	23	28	35	1	21	35	3	15	4	5	20	32	12
13	19	38	50	21	46	38	23	32	14	1	25	15	3	19	0	5	24	41	13
14	19	43	9	21	50	33	23	35	54	1	28	56	3	22	55	5	28	50	14
15	19	47	27	21	54	27	23	39	34	1	32	38	3	26	52	5	32	59	15
16	19	51	45	21	58	20	23	43	13	1	36	19	3	30	49	5	37	9	16
17	19	56	1	22	2	12	23	46	52	1	40	1	3	34	46	5	41	18	17
18	20	0	18	22	6	4	23	50	31	1	43	44	3	38	44	5	45	28	18
19	20	4	33	22	9	55	23	54	9	1	47	26	3	42	43	5	49	37	19
20	20	8	48	22	13	45	23	57	48	1	51	10	3	46	42	5	53	47	20
21	20	13	2	22	17	35	0	1	26	1	54	53	3	50	42	5	57	57	21
22	20	17	15	22	21	24	0	5	4	1	58	37	3	54	42	6	2	7	22
23	20	21	27	22	25	13	0	8	43	2	2	22	3	58	44	6	6	16	23
24	20	25	39	22	29	1	0	12	21	2	6	7	4	2	45	6	10	26	24
25	20	29	50	22	32	48	0	15	59	2	9	53	4	6	47	6	14	35	25
26	20	34	0	22	36	35	0	19	37	2	13	39	4	10	49	6	18	44	26
27	20	38	9	22	40	21	0	23	15	2	17	25	4	14	52	6	22	54	27
28	20	42	18	22	44	6	0	26	53	2	21	12	4	18	56	6	27	3	28
29	20	46	25				0	30	31	2	24	59	4	23	0	6	31	11	29
30	20	50	32				0	34	9	2	28	47	4	27	4	6	35	20	30
31	20	54	38				0	37	47				4	31	8				31

TABLE III.—Continued.

Day.	July.	August.	Sept.	Oct.	Nov.	Dec.	Day.
	h. m. s.	h m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	
1	6 39 28	8 44 22	10 40 30	12 28 35	14 24 45	16 28 29	1
2	6 43 36	8 48 15	10 44 8	12 32 12	14 28 41	16 32 48	2
3	6 47 44	8 52 7	10 47 45	12 35 50	14 32 37	16 37 8	3
4	6 51 52	8 55 59	10 51 22	12 39 28	14 36 34	16 41 29	4
5	6 55 59	8 59 50	10 54 59	12 43 6	14 40 32	16 45 50	5
6	7 0 6	9 3 40	10 58 36	12 46 45	14 44 30	16 50 12	6
7	7 4 12	9 7 30	11 2 12	12 50 24	14 48 30	16 54 34	7
8	7 8 18	9 11 19	11 5 48	12 54 4	14 52 30	16 58 57	8
9	7 12 24	9 15 8	11 9 24	12 57 44	14 56 31	17 3 20	9
10	7 16 30	9 18 56	11 13 0	13 1 24	15 0 34	17 7 44	10
11	7 20 35	9 22 44	11 16 36	13 5 5	15 4 37	17 12 9	11
12	7 24 39	9 26 31	11 20 12	13 8 47	15 8 41	17 16 33	12
13	7 28 43	9 30 18	11 23 48	13 12 29	15 12 45	17 20 58	13
14	7 32 47	9 34 4	11 27 23	13 16 12	15 16 51	17 25 24	14
15	7 36 50	9 37 49	11 30 59	13 19 55	15 20 57	17 29 49	15
16	7 40 53	9 41 34	11 34 34	13 23 38	15 25 5	17 34 15	16
17	7 44 55	9 45 19	11 38 10	13 27 23	15 29 13	17 38 41	17
18	7 48 57	9 49 3	11 41 45	13 31 8	15 33 22	17 43 8	18
19	7 52 58	9 52 46	11 45 21	13 34 53	15 37 32	17 47 34	19
20	7 56 59	9 56 29	11 48 56	13 38 39	15 41 42	17 52 1	20
21	8 0 59	10 0 12	11 52 32	13 42 26	15 45 54	17 56 27	21
22	8 4 59	10 3 54	11 56 8	13 46 13	15 50 6	18 0 54	22
23	8 8 58	10 7 35	11 59 43	13 50 1	15 54 19	18 5 21	23
24	8 12 56	10 11 16	12 3 19	13 53 50	15 58 33	18 9 47	24
25	8 16 54	10 14 57	12 6 55	13 57 39	16 2 47	18 14 14	25
26	8 20 52	10 18 37	12 10 31	14 1 29	16 7 2	18 18 40	26
27	8 24 48	10 22 17	12 14 7	14 5 20	16 11 18	18 23 7	27
28	8 28 44	10 25 56	12 17 44	14 9 12	16 15 35	18 27 33	28
29	8 32 39	10 29 35	12 21 21	14 13 4	16 19 52	18 31 59	29
30	8 36 34	10 33 14	12 24 57	14 16 57	16 24 10	18 36 24	30
31	8 40 28	10 36 52		14 20 51		18 40 50	31

TABLE IV.

Showing the Right Ascension of the Mid-Heaven at 9 o'clock in the evening, for every day in the year.

Day.	January.	February.	March.	April.	May.	June.	Day
	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	
1	3 46 21	5 58 43	7 47 51	9 41 25	11 32 36	13 35 14	1
2	3 50 46	6 2 47	7 51 35	9 45 3	11 36 25	13 39 19	2
3	3 55 11	6 6 50	7 55 19	9 48 42	11 40 14	13 43 25	3
4	3 59 35	6 10 53	7 59 3	9 52 20	11 44 4	13 47 31	4
5	4 3 59	6 14 54	8 2 46	9 55 59	11 47 55	13 51 38	5
6	4 8 22	6 18 55	8 6 28	9 59 57	11 51 46	13 55 45	6
7	4 12 45	6 22 55	8 10 10	10 3 16	11 55 37	13 59 52	7
8	4 17 7	6 26 54	8 13 52	10 6 56	11 59 30	14 3 59	8
9	4 21 29	6 30 53	8 17 33	10 10 35	12 3 22	14 8 7	9
10	4 25 50	6 34 50	8 21 14	10 14 15	12 7 16	14 12 15	10
11	4 30 11	6 38 47	8 24 54	10 17 55	12 11 10	14 16 24	11
12	4 34 31	6 42 43	8 28 35	10 21 35	12 15 4	14 20 32	12
13	4 38 50	6 46 38	8 32 14	10 25 15	12 19 0	14 24 41	13
14	4 43 9	6 50 33	8 35 54	10 28 56	12 22 55	14 28 50	14
15	4 47 27	6 54 27	8 39 34	10 32 38	12 26 52	14 32 59	15
16	4 51 45	6 58 20	8 43 13	10 36 19	12 30 49	14 37 9	16
17	4 56 1	7 2 12	8 46 52	10 40 1	12 34 46	14 41 18	17
18	5 0 18	7 6 4	8 50 31	10 43 44	12 38 44	14 45 28	18
19	5 4 33	7 9 55	8 54 9	10 47 26	12 42 43	14 49 37	19
20	5 8 48	7 13 45	8 57 48	10 51 10	12 46 42	14 53 47	20
21	5 13 2	7 17 35	9 1 26	10 54 53	12 50 42	14 57 57	21
22	5 17 15	7 21 24	9 5 4	10 58 37	12 54 42	15 2 7	22
23	5 21 27	7 25 13	9 8 43	11 2 22	12 58 44	15 6 16	23
24	5 25 39	7 29 1	9 12 21	11 6 7	13 2 45	15 10 26	24
25	5 29 50	7 32 48	9 15 59	11 9 53	13 6 47	15 14 35	25
26	5 34 0	7 36 35	9 19 37	11 13 39	13 10 49	15 18 44	26
27	5 38 9	7 40 21	9 23 15	11 17 25	13 14 52	15 22 54	27
28	5 42 18	7 44 6	9 26 53	11 21 12	13 18 56	15 27 3	28
29	5 46 25		9 30 31	11 24 59	13 23 0	15 31 11	29
30	5 50 32		9 34 9	11 28 47	13 27 4	15 35 20	30
31	5 54 38		9 37 47		13 31 8		31

TABLE IV.—Continued.

Day	July.	August.	Sept.	Oct.	Nov.	Dec.	Day
	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	
1	15 39 28	17 44 22	19 40 30	21 28 35	23 24 45	1 28 29	1
2	15 43 36	17 48 15	19 44 8	21 32 12	23 28 41	1 32 48	2
3	15 47 44	17 52 7	19 47 45	21 35 50	23 32 37	1 37 8	3
4	15 51 52	17 55 59	19 51 22	21 39 28	23 36 34	1 41 29	4
5	15 55 59	17 59 50	19 54 59	21 43 6	23 40 32	1 45 50	5
6	16 0 6	18 3 40	19 58 36	21 46 45	23 44 30	1 50 12	6
7	16 4 12	18 7 30	20 2 12	21 50 24	23 48 30	1 54 34	7
8	16 8 18	18 11 19	20 5 48	21 54 4	23 52 30	1 58 57	8
9	16 12 24	18 15 8	20 9 24	21 57 44	23 56 31	2 3 20	9
10	16 16 30	18 18 56	20 13 0	22 1 24	0 0 34	2 7 44	10
11	16 20 35	18 22 44	20 16 36	22 5 5	0 4 37	2 12 9	11
12	16 24 39	18 26 31	20 20 12	22 8 47	0 8 41	2 16 33	12
13	16 28 43	18 30 18	20 23 48	22 12 29	0 12 45	2 20 58	13
14	16 32 47	18 34 4	20 27 23	22 16 12	0 16 51	2 25 24	14
15	16 36 50	18 37 49	20 30 59	22 19 55	0 20 57	2 29 49	15
16	16 40 53	18 41 34	20 34 34	22 23 38	0 25 5	2 34 15	16
17	16 44 55	18 45 19	20 38 10	22 27 23	0 29 13	2 38 41	17
18	16 48 57	18 49 3	20 41 45	22 31 8	0 33 22	2 43 8	18
19	16 52 58	18 52 46	20 45 21	22 34 53	0 37 32	2 47 34	19
20	16 56 59	19 56 29	20 48 56	22 38 39	0 41 42	2 52 1	20
21	17 0 59	19 0 12	20 52 32	22 42 26	0 45 54	2 56 27	21
22	17 4 59	19 3 54	20 56 8	22 46 13	0 50 6	3 0 54	22
23	17 8 58	19 7 35	20 59 43	22 50 1	0 54 19	3 5 21	23
24	17 12 56	19 11 16	21 3 19	22 53 50	0 58 33	3 9 47	24
25	17 16 54	19 14 57	21 6 55	22 57 39	1 2 47	3 14 14	25
26	17 20 52	19 18 37	21 10 31	23 1 29	1 7 2	3 18 40	26
27	17 24 48	19 22 17	21 14 7	23 5 20	1 11 18	3 23 7	27
28	17 28 44	19 25 56	21 17 44	23 9 12	1 15 35	3 27 33	28
29	17 32 39	19 29 35	21 21 21	23 13 4	1 19 52	3 31 59	29
30	17 36 34	19 33 14	21 24 57	23 16 57	1 24 10	3 36 24	30
31	17 40 28	19 36 52		23 20 51		3 40 50	31

TABLE V.

Exhibiting the Sun's Declination for every day in the year.

Day.	January.	February.	March.	April.	May.	June.	Day.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	
1	23 1 52	17 8 57	7 39 11	4 27 37	15 0 22	22 1 44	1
2	22 56 45	16 51 46	7 16 22	4 50 43	15 18 26	22 9 49	2
3	22 51 10	16 34 18	6 53 27	5 13 44	15 36 16	22 17 30	3
4	22 45 8	16 16 32	6 30 26	5 36 39	15 53 50	22 24 48	4
5	22 38 39	15 58 29	6 7 20	5 59 28	16 11 8	22 31 43	5
6	22 31 43	15 40 11	5 44 9	6 22 11	16 28 10	22 38 14	6
7	22 24 20	15 21 36	5 20 53	6 44 48	16 44 56	22 44 21	7
8	22 16 31	15 2 46	4 57 34	7 7 17	17 1 25	22 50 4	8
9	22 8 16	14 43 40	4 34 10	7 29 40	17 17 37	22 55 23	9
10	21 59 34	14 24 20	4 10 43	7 51 54	17 33 32	23 0 19	10
11	21 50 27	14 4 45	3 47 13	8 14 1	17 49 10	23 4 50	11
12	21 40 55	13 44 56	3 23 40	8 36 0	18 4 30	23 8 56	12
13	21 30 57	13 24 54	3 0 5	8 57 50	18 19 31	23 12 39	13
14	21 20 34	13 4 39	2 36 28	9 19 32	18 34 14	23 15 56	14
15	21 9 47	12 44 11	2 12 49	9 41 4	18 48 39	23 18 50	15
16	20 58 35	12 23 30	1 49 9	10 2 27	19 2 45	23 21 18	16
17	20 47 0	12 2 38	1 25 27	10 23 40	19 16 31	23 23 22	17
18	20 35 0	11 41 34	1 1 45	10 44 44	19 29 58	23 25 1	18
19	20 22 37	11 20 19	0 38 3	11 5 36	19 43 6	23 26 15	19
20	20 9 51	10 58 53	S. 14 21	11 26 18	19 55 53	23 27 5	20
21	19 56 43	10 37 17	N. 9 20	11 46 48	20 8 20	23 27 30	21
22	19 43 12	10 15 31	0 33 1	12 7 8	20 20 26	23 27 29	22
23	19 29 19	9 53 36	0 56 41	12 27 15	20 32 12	23 27 4	23
24	19 15 4	9 31 31	1 20 18	12 47 10	20 43 36	23 26 15	24
25	19 0 28	9 9 19	1 43 54	13 6 52	20 54 40	23 25 0	25
26	18 45 31	8 46 58	2 7 28	13 26 21	21 5 21	23 23 21	26
27	18 30 14	8 24 59	2 30 58	13 45 37	21 15 41	23 21 17	27
28	18 14 37	8 1 53	2 54 26	14 4 40	21 25 38	23 18 48	28
29	17 58 40		3 17 50	14 23 28	21 35 14	23 15 55	29
30	17 42 24		3 41 10	14 42 2	21 44 27	23 12 38	30
31	17 25 50		4 4 26		21 53 17		31

TABLE V.—Continued.

Day.	July.			August.			Sept.			Oct.			Nov.			Dec.			Day.
	°	′	″	°	′	″	°	′	″	°	′	″	°	′	″	°	′	″	
1	23	8	56	18	6	40	8	23	33	3	5	22	14	22	19	21	47	34	1
2	23	4	49	17	51	30	8	1	44	3	28	40	14	41	30	21	56	46	2
3	23	0	19	17	36	2	7	39	48	3	51	56	15	0	27	22	5	34	3
4	22	55	25	17	20	17	7	17	44	4	15	9	15	19	9	22	13	55	4
5	22	50	6	17	4	16	6	55	32	4	38	20	15	37	37	22	21	51	5
6	22	44	24	16	47	58	6	33	14	5	1	27	15	55	49	22	29	21	6
7	22	38	18	16	31	23	6	10	49	5	24	30	16	13	45	22	36	25	7
8	22	31	49	16	14	32	5	48	18	5	47	30	16	31	25	22	43	2	8
9	22	24	56	15	57	26	5	25	41	6	10	25	16	48	48	22	49	12	9
10	22	17	40	15	40	4	5	2	59	6	33	15	17	5	55	22	54	55	10
11	22	10	1	15	22	27	4	40	11	6	56	0	17	22	43	23	0	11	11
12	22	1	59	15	4	35	4	17	18	7	18	40	17	39	14	23	5	0	12
13	21	53	34	14	46	29	3	54	20	7	41	14	17	55	27	23	9	21	13
14	21	44	46	14	28	8	3	31	19	8	3	41	18	11	21	23	13	14	14
15	21	35	37	14	9	33	3	8	13	8	26	2	18	26	55	23	16	40	15
16	21	26	5	13	50	45	2	45	3	8	48	16	18	42	10	23	19	38	16
17	21	16	11	13	31	43	2	21	51	9	10	22	18	57	5	23	22	7	17
18	21	5	55	13	12	28	1	58	36	9	32	21	19	11	40	23	24	9	18
19	20	55	18	12	53	1	1	35	18	9	54	11	19	25	54	23	25	42	19
20	20	44	20	12	33	22	1	11	58	10	15	52	19	39	47	23	26	47	20
21	20	33	1	12	13	30	0	48	36	10	37	24	19	53	19	23	27	24	21
22	20	21	20	11	53	27	0	25	13	10	58	47	20	6	28	23	27	32	22
23	20	9	20	11	33	13	N.	1	49	11	19	59	20	19	15	23	27	13	23
24	19	56	50	11	12	48	S.	21	36	11	41	1	20	31	40	23	26	24	24
25	19	44	19	10	52	12	0	45	1	12	1	53	20	43	42	23	25	8	25
26	19	31	18	10	31	26	1	8	27	12	22	33	20	55	21	23	23	23	26
27	19	17	59	10	10	31	1	31	52	12	43	2	21	6	36	23	21	10	27
28	19	4	20	9	49	25	1	55	16	13	3	19	21	17	27	23	18	29	28
29	18	50	22	9	28	10	2	18	40	13	23	23	21	27	54	23	15	20	29
30	18	36	6	9	6	46	2	42	2	13	43	15	21	37	56	23	11	43	30
31	18	21	32	8	45	14				14	2	54				23	7	38	31

TABLE VI.

Exhibiting the Sun's mean place in the Ecliptic, or its Longitude, together with the Right Ascension, for every day in the year.

Day.	January.				February.				March.				April.			
	Long.		R. A.		Long.		R. A.		Long.		R. A.		Long.		R. A.	
	°	'	°	'	°	'	°	'	°	'	°	'	°	'	°	'
1	280	39	281	35	312	13	314	41	340	27	341	58	11	16	10	21
2	281	41	282	41	313	14	315	42	341	28	342	54	12	15	11	16
3	282	42	283	48	314	14	316	42	342	28	343	50	13	14	12	10
4	283	43	284	54	315	15	317	43	343	28	344	46	14	13	13	5
5	284	44	286	0	316	16	318	43	344	28	345	41	15	12	14	0
6	285	45	287	5	317	17	319	44	345	28	346	37	16	11	14	54
7	286	46	288	11	318	17	320	46	346	28	347	32	17	10	15	49
8	287	48	289	17	319	18	321	44	347	28	348	28	18	9	16	44
9	288	49	290	22	320	19	322	43	348	27	349	23	19	8	17	39
10	289	50	291	28	321	19	323	43	349	27	350	18	20	6	18	34
11	290	51	292	33	322	20	324	41	350	27	351	13	21	5	19	29
12	291	52	293	38	323	21	325	40	351	27	352	9	22	4	20	24
13	292	53	294	43	324	21	326	40	352	27	353	4	23	3	21	19
14	293	54	295	47	325	22	327	38	353	26	353	59	24	1	22	14
15	294	55	296	52	326	22	328	37	354	26	354	53	25	00	23	9
16	295	57	297	56	327	23	329	35	355	26	355	48	25	59	24	5
17	296	58	299	0	328	23	330	33	356	25	356	43	26	57	25	0
18	297	59	300	4	329	24	331	31	357	25	357	38	27	56	25	56
19	299	0	301	8	330	24	332	29	358	24	358	32	28	54	26	51
20	300	1	302	12	331	25	333	27	359	24	359	27	29	53	27	47
21	301	2	303	15	332	25	334	24	000	24	0	22	30	51	28	43
22	302	3	304	19	333	26	335	21	1	23	1	16	31	50	29	39
23	303	4	305	22	334	26	336	18	2	22	2	10	32	48	30	35
24	304	5	306	25	335	26	337	15	3	22	3	5	33	47	31	32
25	305	6	307	27	336	27	338	12	4	21	4	0	34	45	32	28
26	306	7	308	30	337	27	339	9	5	21	4	54	35	43	33	25
27	307	8	309	32	338	27	340	5	6	20	5	49	36	42	34	21
28	308	9	310	34	339	27	341	2	7	19	6	42	37	40	35	18
29	309	10	311	36					8	18	7	38	38	38	36	15
30	310	11	312	38					9	18	8	32	39	36	37	12
31	311	12	313	39					10	17	9	27				

TABLE VI.—Continued.

Day.	May.				June.				July.				August.			
	Long.		R. A.		Long.		R. A.		Long.		R. A.		Long.		R. A.	
	°	′	°	′	°	′	°	′	°	′	°	′	°	′	°	′
1	40	34	38	9	70	25	68	48	99	4	99	52	128	40	131	5
2	41	32	39	6	71	23	69	50	100	1	100	54	129	37	132	4
3	42	31	40	3	72	20	70	51	100	59	101	56	130	35	133	2
4	43	29	41	1	73	18	71	53	101	56	102	58	131	32	134	0
5	44	27	41	59	74	15	72	54	102	53	104	0	132	29	135	0
6	45	25	42	56	75	12	73	56	103	50	105	1	133	27	135	55
7	46	23	43	54	76	10	74	58	104	47	106	3	134	24	136	53
8	47	21	44	52	77	7	76	0	105	44	107	5	135	22	137	50
9	48	19	45	6	78	4	77	2	106	42	108	6	136	20	138	47
10	49	16	46	49	79	2	78	4	107	39	109	7	137	17	139	44
11	50	14	47	47	79	59	79	6	108	36	110	9	138	15	140	41
12	51	12	48	46	80	56	80	8	109	33	111	10	139	12	141	38
13	52	10	49	45	81	54	81	10	110	31	112	11	140	10	142	34
14	53	8	50	44	82	51	82	13	111	28	113	12	141	8	143	31
15	54	6	51	42	83	48	83	15	112	25	114	13	142	5	144	27
16	55	3	52	42	84	46	84	17	113	22	115	13	143	3	145	24
17	56	1	53	41	85	43	85	20	114	20	116	14	144	1	146	20
18	56	59	54	41	86	40	86	22	115	17	117	14	144	59	147	16
19	57	57	55	41	87	37	87	24	116	14	118	15	145	56	148	12
20	58	54	56	41	88	35	88	27	117	11	119	15	146	54	149	7
21	59	52	57	41	89	32	89	30	118	9	120	15	147	52	150	3
22	60	50	58	41	90	29	90	32	119	6	121	15	148	50	150	58
23	61	47	59	41	91	26	91	34	120	3	122	14	149	48	151	54
24	62	45	60	41	92	24	92	36	121	1	123	14	150	46	152	49
25	63	43	61	42	93	21	93	39	121	58	124	14	151	44	153	44
26	64	40	62	42	94	18	94	41	122	55	125	13	152	42	154	39
27	65	38	63	43	95	15	95	43	123	53	126	12	153	39	155	34
28	66	35	64	44	96	13	96	46	124	50	127	11	154	37	156	29
29	67	33	65	45	97	10	97	48	125	48	128	10	155	35	157	24
30	68	30	66	46	98	7	98	50	126	45	129	9	156	34	158	18
31	69	28	67	47					127	42	130	7	157	32	159	13

TABLE VI.—Continued.

Day	September.		October.		November.		December.	
	Long.	R. A.	Long.	R. A.	Long.	R. A.	Long.	R. A.
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
1	158 30	160 8	187 47	187 9	218 34	216 11	248 50	247 7
2	159 28	161 2	188 46	188 3	219 35	217 10	249 51	248 12
3	160 26	161 55	189 45	188 57	220 35	218 9	250 52	249 17
4	161 24	162 51	190 44	189 52	221 35	219 8	251 53	250 22
5	162 22	163 45	191 43	190 47	222 35	220 8	252 54	251 28
6	163 20	164 39	192 43	191 41	223 35	221 8	253 55	252 33
7	164 19	165 33	193 42	192 36	224 36	222 7	254 56	253 39
8	165 17	166 27	194 41	193 31	225 36	223 8	255 57	254 44
9	166 15	167 21	195 40	194 26	226 36	224 8	256 58	255 50
10	167 14	168 15	196 40	195 21	227 37	225 8	257 59	256 55
11	168 12	169 9	197 39	196 16	228 37	226 9	258 0	258 2
12	169 11	170 3	198 39	197 12	229 37	227 10	260 1	259 8
13	170 9	170 57	199 38	198 7	230 38	228 11	261 2	260 15
14	171 8	171 51	200 38	199 3	231 38	229 13	262 3	261 21
15	172 6	172 45	201 37	199 59	232 39	230 14	263 4	262 27
16	173 5	173 39	202 37	200 55	233 39	231 16	264 6	263 34
17	174 3	174 32	203 36	201 51	234 40	232 18	265 7	264 40
18	175 2	175 26	204 36	202 47	235 41	233 20	266 8	265 47
19	176 1	176 20	205 36	203 43	236 41	234 23	267 9	266 54
20	176 59	177 14	206 35	204 40	237 42	235 26	268 10	268 0
21	177 58	178 8	207 35	205 36	238 43	236 28	269 11	269 7
22	178 57	179 2	208 35	206 33	239 43	237 31	270 12	270 14
23	179 56	179 56	209 35	207 30	240 44	238 35	271 14	271 20
24	180 54	180 50	210 35	208 27	241 45	239 38	272 15	272 27
25	181 53	181 44	211 35	209 25	242 45	240 42	273 16	273 34
26	182 52	182 38	212 34	210 22	243 46	241 46	274 17	274 40
27	183 51	183 32	213 34	211 20	244 47	242 50	275 18	275 47
28	184 50	184 26	214 34	212 18	245 48	243 54	276 19	276 53
29	185 49	185 20	215 34	213 16	246 49	244 58	277 21	278 0
30	186 48	186 14	216 34	214 14	247 50	246 2	278 22	279 6
31			217 34	215 13			279 23	280 13

TABLE VII.

Exhibiting the Right Ascension and Declination of the Planets, and the time of their passing the Meridian, for 1833.

Months.	Days.	Venus.			Mars.			Jupiter.			Saturn.		
		R. ascension.	Declination.	Pass Mer.	R. ascension.	Declination.	Pass Mer.	R. ascension.	Declination.	Pass Mer.	R. ascension.	Declination.	Pass Mer.
		h. m.	° ′	h. m.	h. m.	° ′	h. m.	h. m.	° ′	h. m.	h. m.	° ′	h. m.
January.	1	21 30	16 44	2 42	3 13	20 8	8 24	23 35	4 6	4 46	11 57	2 48	17 6
	7	21 58	14 12	2 44	3 16	20 22	8 1	23 38	3 43	4 24	11 57	2 49	16 40
	13	22 25	11 27	2 45	3 21	20 41	7 40	23 42	3 18	4 1	11 57	2 51	16 14
	19	22 51	8 32	2 46	3 27	21 4	7 21	23 46	2 52	3 39	11 56	2 55	15 48
	25	23 17	5 31	2 46	3 35	21 29	7 3	23 50	2 24	3 18	11 56	3 0	15 22
February.	1	23 46	1 54	2 47	3 44	22 2	6 44	23 55	1 49	2 55	11 55	3 9	14 52
	7	0 11	1 14	2 47	3 54	22 29	6 29	23 59	1 19	2 35	11 54	3 17	14 27
	13	0 35	4 20	2 47	4 4	22 57	6 16	0 4	0 47	2 16	11 53	3 26	14 3
	19	0 58	7 23	2 47	4 15	23 24	6 4	0 9	0 15	1 58	11 51	3 36	13 38
	25	1 22	10 19	2 48	4 27	23 50	5 53	0 14	0 18	1 40	11 50	3 47	13 14
March.	1	1 37	12 11	2 48	4 35	24 5	5 46	0 17	0 40	1 28	11 49	3 54	12 58
	7	1 59	14 53	2 48	4 48	24 27	5 36	0 23	1 14	1 11	11 47	4 6	12 34
	13	2 22	17 22	2 48	5 1	24 45	5 28	0 28	1 48	0 54	11 45	4 18	12 10
	19	2 43	19 37	2 48	5 15	24 59	5 19	0 33	2 23	0 38	11 44	4 29	11 46
	25	3 3	21 36	2 46	5 28	25 9	5 11	0 38	2 57	0 21	11 42	4 40	11 23
April.	1	3 24	23 33	2 42	5 45	25 16	5 2	0 45	3 37	0 2	11 40	4 53	10 56
	7	3 40	24 53	2 36	5 59	25 16	4 55	0 50	4 11	23 43	11 38	5 2	10 32
	13	3 53	25 51	2 26	6 14	25 11	4 47	0 55	4 44	23 26	11 37	5 11	10 9
	19	4 1	26 26	2 13	6 29	25 2	4 40	1 1	5 17	23 9	11 36	5 19	9 46
	25	4 5	26 33	1 54	6 44	24 46	4 33	1 6	5 50	22 52	11 34	5 25	9 23
May	1	4 3	26 8	1 29	6 59	24 26	4 25	1 11	6 22	22 35	11 34	5 30	8 58
	7	3 54	25 4	0 58	7 14	24 0	4 17	1 16	6 53	22 17	11 33	5 34	8 35
	13	3 42	23 22	0 21	7 29	23 29	4 8	1 21	7 23	21 58	11 32	5 36	8 11
	19	3 27	21 13	23 37	7 44	22 52	4 0	1 26	7 52	21 40	11 32	5 37	7 47
	25	3 15	18 58	23 2	7 59	22 11	3 50	1 31	8 20	21 20	11 32	5 36	7 23
June.	1	3 6	16 45	22 25	8 16	21 16	3 39	1 37	8 51	20 57	11 32	5 34	6 54
	7	3 4	15 28	21 59	8 31	20 23	3 30	1 41	9 11	20 37	11 32	5 30	6 30
	13	3 7	14 50	21 39	8 46	19 26	3 19	1 46	9 40	20 17	11 33	5 24	6 6
	19	3 15	14 44	21 22	9 0	18 25	3 9	1 50	10 2	19 56	11 34	5 18	5 42
	25	3 27	15 5	21 10	9 15	17 19	2 59	1 54	10 23	19 35	11 35	5 10	5 18

TABLE VII. for 1833—Continued.

Months.	Days.	Venus.			Mars.			Jupiter.			Saturn.		
		R. ascension.	Declination.	Pass Mer.	R. ascension.	Declination.	Pass Mer.	R. ascension.	Declination.	Pass Mer.	R. ascension.	Declination.	Pass Mer.
		h. m.	° ′	h. m.	h. m.	° ′	h. m.	h. m.	° ′	h. m.	h. m.	° ′	h. m
July.	1	3 42	15 43	21 0	9 29	16 9	2 48	1 57	10 42	19 14	11 36	5 1	4 55
	7	3 59	16 33	20 53	9 43	14 56	2 38	2 1	10 59	18 53	11 38	4 50	4 31
	13	4 19	17 30	20 48	9 58	13 9	2 28	2 4	11 15	18 31	11 39	4 39	4 9
	19	4 40	18 25	20 46	10 12	12 19	2 18	2 7	11 28	18 10	11 41	4 26	3 46
	25	5 3	19 17	20 45	10 26	10 56	2 8	2 9	11 40	17 48	11 43	4 13	3 24
August.	1	5 32	20 6	20 46	10 42	9 15	1 56	2 11	11 51	17 23	11 45	3 56	2 59
	7	5 58	20 36	20 49	10 56	7 47	1 47	2 13	11 57	17 2	11 47	3 41	2 39
	13	6 24	20 51	20 53	11 10	6 17	1 38	2 14	12 2	16 40	11 50	3 26	2 18
	19	6 52	20 49	20 58	11 24	4 45	1 30	2 15	12 4	16 19	11 52	3 10	1 58
	25	7 20	20 30	21 3	11 38	3 11	1 22	2 15	12 4	15 57	11 55	2 53	1 39
Septem.	1	7 53	19 43	21 12	11 55	1 21	1 13	2 15	12 1	15 31	11 58	2 33	1 16
	7	8 21	18 42	21 19	12 9	0 15	1 6	2 14	11 56	15 9	12 0	2 16	0 57
	13	8 50	17 22	21 26	12 23	1 51	0 59	2 13	11 48	14 46	12 3	1 58	0 38
	19	9 18	15 45	21 33	12 38	3 26	0 51	2 11	11 39	14 23	12 6	1 41	0 19
	25	9 46	13 51	21 39	12 52	5 2	0 44	2 9	11 27	13 59	12 8	1 23	0 1
October.	1	10 14	11 42	21 45	13 7	6 37	0 37	2 7	11 14	13 35	12 11	1 6	23 38
	7	10 41	9 20	21 51	13 22	8 10	0 30	2 4	11 0	13 11	12 14	0 48	23 19
	13	11 9	6 48	21 56	13 37	9 43	0 23	2 1	10 44	12 46	12 17	0 31	23 0
	19	11 36	4 8	22 1	13 52	11 13	0 16	1 58	10 27	12 20	12 19	0 15	22 40
	25	12 3	1 21	22 5	14 8	12 41	0 9	1 55	10 11	11 54	12 22	0 1	22 20
Novem.	1	12 35	1 57	22 10	14 26	14 19	0 1	1 52	9 52	11 24	12 25	0 19	21 56
	7	13 2	4 48	22 13	14 43	15 40	23 52	1 49	9 36	10 57	12 27	0 34	21 34
	13	13 30	7 36	22 17	14 59	16 57	23 44	1 46	9 22	10 30	12 29	0 47	21 12
	19	13 58	10 18	22 20	15 16	18 9	23 36	1 43	9 9	10 3	12 32	1 0	20 50
	25	14 27	12 53	22 23	15 33	19 16	23 28	1 41	8 59	9 35	12 34	1 12	20 26
Decem.	1	14 56	15 17	22 27	15 51	20 17	23 20	1 40	8 50	9 8	12 36	1 23	20 2
	7	15 26	17 28	22 31	16 9	21 11	23 12	1 38	8 45	8 41	12 37	1 32	19 38
	13	15 57	19 21	22 35	16 27	21 59	23 4	1 37	8 42	8 14	12 39	1 40	19 13
	19	16 28	20 55	22 40	16 46	22 40	22 56	1 37	8 41	7 47	12 40	1 47	18 48
	25	17 0	22 8	22 45	17 5	23 13	22 48	1 37	8 44	7 20	12 41	1 53	18 23

TABLE VII. for 1836.

Months.	Days.	Venus. R. ascension.	Venus. Declination.	Venus. Pass Mer.	Mars. R. ascension.	Mars. Declination.	Mars. Pass Mer.	Jupiter. R. ascension.	Jupiter. Declination.	Jupiter. Pass Mer.	Saturn. R. ascension.	Saturn. Declination.	Saturn. Pass Mer.
		h. m.	° ′	h. m.	h. m.	° ′	h. m.	h. m.	° ′	h. m.	h. m.	°	h. m.
January.	1	20 18	21 17	1 37	18 31	24 5	23 49	6 48	23 4	12 5	14 9	10 31	19 25
	5	20 38	20 8	1 42	18 44	23 55	23 47	6 45	23 7	11 47	14 10	10 35	19 11
	10	21 4	18 29	1 48	19 1	23 36	23 44	6 42	23 11	11 24	14 11	10 41	18 52
	15	21 29	16 37	1 53	19 17	23 11	23 41	6 40	23 14	11 2	14 12	10 45	19 34
	20	21 53	14 33	1 58	19 34	22 39	23 38	6 37	23 17	10 40	14 13	10 48	18 15
	25	22 17	12 20	2 2	19 50	22 1	23 35	6 35	23 20	10 17	14 14	10 15	17 56
February.	1	22 50	9 0	2 7	20 13	20 57	23 30	6 32	23 23	9 47	14 15	10 53	17 29
	5	23 8	7 1	2 9	20 26	20 16	23 27	6 30	23 25	9 30	14 15	10 53	17 14
	10	23 30	4 27	2 12	20 43	19 19	23 23	6 28	23 27	9 8	14 15	10 53	15 54
	15	23 54	1 51	2 14	20 58	18 17	23 20	6 27	23 28	8 48	14 15	10 52	16 35
	20	0 15	0 46	2 17	21 14	17 10	23 16	6 26	23 29	8 27	14 15	10 50	16 15
	25	0 37	3 23	2 19	21 30	15 58	23 11	6 26	23 30	8 7	14 15	10 47	15 55
March.	1	0 59	5 59	2 21	21 45	14 42	23 7	6 26	23 31	7 47	14 15	10 44	15 35
	5	1 16	8 1	2 23	21 57	13 39	23 4	6 26	23 31	7 32	14 14	10 41	15 18
	10	1 38	10 30	2 26	22 13	12 17	22 59	6 26	23 31	7 12	14 13	10 36	14 58
	15	2 1	12 52	2 28	22 28	10 53	22 54	6 27	23 31	6 54	14 13	10 30	14 38
	20	2 23	15 8	2 31	22 42	9 25	22 49	6 28	23 31	6 35	14 12	10 24	14 17
	25	2 46	17 14	2 34	22 57	7 56	22 44	6 29	23 30	6 17	14 10	10 18	13 56
April.	1	3 18	19 54	2 39	23 17	5 48	22 37	6 32	23 49	5 52	14 9	10 8	13 27
	5	3 37	21 15	2 42	23 29	4 34	22 33	6 34	23 28	5 38	14 8	10 2	13 10
	10	4 1	22 44	2 46	23 43	3 1	22 27	6 36	23 26	5 20	14 6	9 54	12 49
	15	4 25	24 0	2 50	23 57	1 27	22 22	6 39	23 24	5 3	14 5	9 46	12 28
	20	4 49	25 0	2 54	0 12	0 6	22 16	6 42	23 22	4 47	14 3	9 38	12 7
	25	5 13	25 45	2 59	0 26	1 39	22 11	6 45	23 19	4 30	14 2	9 31	11 46
May	1	5 41	26 19	3 3	0 43	3 30	22 4	6 49	23 15	4 10	14 0	9 22	11 20
	5	6 0	26 28	3 6	0 54	4 43	21 59	6 52	23 11	3 58	13 59	9 16	11 4
	10	6 22	26 27	3 9	1 8	6 12	21 54	6 55	23 7	3 42	13 58	9 9	10 43
	15	6 44	26 10	3 11	1 22	7 40	21 48	6 59	23 2	3 26	13 56	9 2	10 22
	20	7 6	25 40	3 13	1 36	9 5	21 43	7 3	22 57	3 10	13 55	8 56	10 1
	25	7 25	24 58	3 13	1 50	10 28	21 37	7 7	22 51	2 54	13 54	8 51	9 40
June.	1	7 51	23 41	3 11	2 10	12 19	21 29	7 13	22 41	2 33	13 53	8 45	9 11
	5	8 4	22 49	3 8	2 22	13 20	21 25	7 17	22 35	2 21	13 52	8 42	8 55
	10	8 19	21 39	3 32	2 36	14 32	21 20	7 21	22 27	2 5	13 51	8 39	8 34
	15	8 31	20 25	2 56	2 50	15 41	21 14	7 26	22 19	1 50	13 51	8 37	8 14
	20	8 41	19 9	2 46	3 5	16 46	21 9	7 30	22 9	1 35	13 51	8 36	7 54
	25	8 45	17 54	2 34	3 19	17 47	21 4	7 35	22 0	1 20	13 50	8 36	7 34

TABLE VII. for 1836—Continued.

Months.	Days.	Venus.			Mars.			Jupiter.			Saturn.		
		R.as-cen-sion.	Dec-lina-tion.	Pass Mer.	R.as-cen-sion.	Dec-lina-tion.	Pass Mer.	R.as-cen-sion.	Dec-lina-tion.	Pass Mer.	R.as-cen-sion.	Dec-lina-tion.	Pass Mer
		h. m.	° ′	h. m.	h. m.	° ′	h. m.	h. m.	° ′	h. m.	h. m.	° ′	h. m.
July.	1	8 53	16 29	2 14	3 37	18 54	20 58	7 40	21 47	1 2	13 50	8 36	7 10
	5	8 52	15 39	1 58	3 48	19 35	20 53	7 44	21 38	0 50	13 50	8 38	6 55
	10	8 48	14 44	1 34	4 3	20 22	20 48	7 49	21 27	0 35	13 50	8 40	6 35
	15	8 40	14 2	1 7	4 18	21 4	20 43	7 54	21 15	0 20	13 50	8 43	6 16
	20	8 29	13 35	0 36	4 32	21 41	20 38	7 58	21 3	0 5	13 51	8 47	5 57
	25	8 17	13 21	24 0	4 47	22 13	20 33	8 3	20 50	23 47	13 51	8 52	5 38
August.	1	7 59	13 24	23 12	5 7	22 50	20 26	8 9	20 31	23 26	13 52	9 0	5 11
	5	7 51	13 35	22 49	5 19	23 6	20 22	8 13	20 20	23 14	13 53	9 5	4 56
	10	7 44	13 54	22 24	5 33	23 22	20 16	8 18	20 6	22 59	13 54	9 13	4 38
	15	7 41	14 16	22 2	5 47	23 33	20 11	8 22	19 52	22 44	13 54	9 20	4 19
	20	7 43	14 38	22 44	6 1	23 40	20 5	8 21	19 37	22 28	13 57	9 29	4 1
	25	7 48	14 58	21 30	6 15	23 42	19 59	8 31	19 22	22 13	13 58	9 38	3 43
September.	1	8 0	15 14	21 16	6 35	23 37	19 51	8 37	19 2	21 51	14 0	9 51	3 17
	5	8 10	15 17	21 10	6 45	23 31	19 50	8 40	18 50	21 39	14 2	10 0	3 3
	10	8 23	15 11	21 4	6 59	23 19	19 40	8 44	18 35	21 23	14 4	10 10	2 45
	15	8 39	14 54	21 0	7 12	23 4	19 33	8 48	18 21	21 7	14 6	10 21	2 27
	20	8 55	14 26	20 57	7 25	22 46	19 26	8 52	18 7	20 51	14 7	10 32	2 10
	25	9 13	13 46	20 56	7 37	22 25	19 18	8 55	17 52	20 35	14 9	10 44	1 52
October.	1	9 36	12 41	20 55	7 52	21 55	19 10	9 0	17 37	20 16	14 12	10 58	1 31
	5	9 52	11 49	20 55	8 1	21 34	19 3	9 2	17 26	20 3	14 14	11 7	1 17
	10	10 12	10 33	20 55	8 13	21 6	18 55	9 5	17 14	19 46	14 16	11 19	0 59
	15	10 32	9 6	20 56	8 24	20 36	18 46	9 8	17 2	19 29	14 18	11 31	0 42
	20	10 52	7 30	20 57	8 35	20 6	18 37	9 11	16 51	19 12	14 20	11 43	0 25
	25	11 13	5 46	20 58	8 45	19 35	18 28	9 13	16 41	18 55	14 23	11 55	0 7
November.	1	11 43	3 7	21 0	8 59	18 51	18 14	9 16	16 29	18 30	14 26	12 11	23 39
	5	12 0	1 31	21 1	9 6	18 26	18 5	9 18	16 23	18 16	14 28	12 20	23 26
	10	12 21	0 33	21 3	9 15	17 56	17 54	9 19	16 17	17 58	14 30	12 32	23 8
	15	12 43	2 40	21 5	9 23	17 27	17 43	9 21	16 12	17 40	14 33	12 43	22 51
	20	13 5	4 48	21 7	9 31	17 0	17 31	9 22	16 8	17 21	14 35	12 56	22 33
	25	13 27	6 57	21 10	9 37	16 37	17 18	9 23	16 6	17 2	14 37	13 4	22 16
December.	1	13 54	9 28	21 13	9 45	16 12	17 1	9 23	16 5	16 39	14 40	13 16	21 55
	5	14 13	11 7	21 16	9 49	15 59	16 50	9 23	16 6	16 23	14 41	13 24	21 41
	10	14 36	13 5	21 20	9 54	15 47	16 35	9 23	16 8	16 3	14 44	13 33	21 24
	15	15 0	14 57	21 24	9 57	15 39	16 18	9 22	16 12	15 43	14 46	13 42	21 6
	20	15 24	16 41	21 29	10 0	15 38	16 1	9 22	16 17	15 22	14 48	13 50	20 49
	25	15 49	18 13	21 34	10 1	15 42	15 43	9 20	16 24	15 2	14 49	13 58	20 36

TABLE VIII.

To change degrees, minutes, and seconds of the equator, or of right ascension, into hours, minutes, and seconds, of sidereal time.

Deg. Mi. Sec.	H. M. M. S. S. Th.	Deg. Mi. Sec.	H. M. M. S. S. Th.	Degrees.	Hours. Minutes.
1	0 4	31	2 4	70	4 40
2	0 8	32	2 8	80	5 20
3	0 12	33	2 12	90	6 0
4	0 16	34	2 16	100	6 40
5	0 20	35	2 20	110	7 20
6	0 24	36	2 24	120	8 0
7	0 28	37	2 28	130	8 40
8	0 32	38	2 32	140	9 20
9	0 36	39	2 36	150	10 0
10	0 40	40	2 40	160	10 40
11	0 44	41	2 44	170	11 20
12	0 48	42	2 48	180	12 0
13	0 52	43	2 52	190	12 40
14	0 56	44	2 56	200	13 20
15	1 0	45	3 0	210	14 0
16	1 4	46	3 4	220	14 40
17	1 8	47	3 8	230	15 20
18	1 12	48	3 12	240	16 0
19	1 16	49	3 16	250	16 40
20	1 20	50	3 20	260	17 20
21	1 24	51	3 24	270	18 0
22	1 28	52	3 28	280	18 40
23	1 32	53	3 32	290	19 20
24	1 36	54	3 36	300	20 0
25	1 40	55	3 40	310	20 40
26	1 44	56	3 44	320	21 20
27	1 48	57	3 48	330	22 0
28	1 52	58	3 52	340	22 40
29	1 56	59	3 56	350	23 20
30	2 [illegible]	[illegible]	[illegible] 0	[illegible]60	24 0

TABLE IX.

To change hours, minutes, and seconds, of sidereal time, into degrees, minutes, and seconds, of the equator, or right ascension.

Hours.	Degrees.	Min. Sec. Th.	D. M. M. S. S. Th.	Min. Sec. Th.	D. M. M. S. S. Th.
1	15	1	0 15	31	7 45
2	30	2	0 30	32	8 0
3	45	3	0 45	33	8 15
4	60	4	1 0	34	8 30
5	75	5	1 15	35	8 45
6	90	6	1 30	36	9 0
7	105	7	1 45	37	9 15
8	120	8	2 0	38	9 30
9	135	9	2 15	39	9 45
10	150	10	2 30	40	10 0
11	165	11	2 45	41	10 15
12	180	12	3 0	42	10 30
13	195	13	3 15	43	10 45
14	210	14	3 30	44	11 0
15	225	15	3 45	45	11 15
16	240	16	4 0	46	11 30
17	255	17	4 15	47	11 45
18	270	18	4 30	48	12 0
19	285	19	4 45	49	12 15
20	300	20	5 0	50	12 30
21	315	21	5 15	51	12 45
22	330	22	5 30	52	13 0
23	345	23	5 45	53	13 15
24	360	24	6 0	54	13 30
25	375	25	6 15	55	13 45
26	390	26	6 30	56	14 0
27	405	27	6 45	57	14 15
28	420	28	7 0	58	14 30
29	435	29	7 15	59	14 45
30	[illegible]50	30	7 30	60	15 [illegible]

TABLE X.

Showing how many miles make a degree of longitude, in every degree of latitude.

Deg. Lat.	Geo. Miles.	Eng. Miles.	Deg. Lat.	Geo. Miles.	Eng. Miles	Deg. Lat.	Geo. Miles	Eng. Miles
1	59.99	69.06	31	51.43	59.13	61	29.09	33.45
2	59.96	69.03	32	50.88	58.51	62	28.17	32.40
3	59.92	68.97	33	50.32	57.87	63	27.24	31.33
4	59.85	68.90	34	49.74	57.20	64	26.30	30.24
5	59.77	68.81	35	49.15	56.51	65	25.36	29.15
6	59.67	68.62	36	48.54	55.81	66	24.40	28.06
7	59.55	68.48	37	47.92	55.10	67	23.45	26.96
8	59.42	68.31	38	47.28	54.37	68	22.48	25.85
9	59.26	68.15	39	46.63	53.62	69	21.50	24.73
10	59.09	67.95	40	45.96	52.85	70	20.52	23.60
11	58.89	67.73	41	45.28	52.07	71	19.53	22.47
12	58.69	67 48	42	44.59	51.27	72	18.54	21.32
13	58.46	67.21	43	43.88	50.46	73	17.54	20.17
14	58.22	66.95	44	43.16	49.63	74	16.54	19.02
15	57.95	66.65	45	42.43	48.78	75	15.53	17.86
16	57.67	66.31	46	41.68	47.93	76	14.52	16.70
17	57.38	65.98	47	40.92	47.06	77	13.50	15.52
18	57.06	65.62	48	40.15	46.16	78	12.48	14.35
19	56.73	65.24	49	39.36	45.26	79	11.45	13.17
20	56.38	64.84	50	38.57	44.35	80	10.42	11.98
21	56.01	64.42	51	37.76	43.42	81	9.38	10.79
22	55.63	63.97	52	36.94	42.48	82	8.35	9.59
23	55.23	63.51	53	36.11	41.53	83	7.31	8.41
24	54.81	63.03	54	35.27	40.56	84	6.27	7.21
25	54.38	62.53	55	34.41	39.58	85	5.22	6.00
26	53.93	62.02	56	33.53	38 58	86	4.18	4.81
27	53.46	61.48	57	32.68	37.58	87	3.14	3.61
28	52.97	60.93	58	31.79	36.57	88	2.09	2.41
29	52.48	60.35	59	30.90	35.54	89	1.05	1.21
29	51.96	59.75	60	30.00	34.50	90	0 00	0.00

TABLE XI.

Of the Climates between the Equator and the Polar Circles.

Climates.	Ends in Lat.	Where the longest day is.	Breadths of the Climates.
	d. m.	h. m.	d. m.
1	8 34	12 30	8 34
2	16 44	13 00	8 10
3	24 12	13 30	7 28
4	30 48	14 00	6 36
5	36 31	14 30	5 43
6	41 24	15 00	4 53
7	45 32	15 30	4 8
8	49 2	16 00	3 30
9	51 59	16 30	2 57
10	54 30	17 00	2 31
11	56 38	17 30	2 8
12	58 27	18 00	1 49
13	59 59	18 30	1 32
14	61 18	19 00	1 19
15	62 26	19 30	1 8
16	63 22	20 00	56
17	64 10	20 30	48
18	64 50	21 00	40
19	65 22	21 30	32
20	65 48	22 00	26
21	66 5	22 30	17
22	66 21	23 00	16
23	66 29	23 30	3
24	66 32	24 00	3

TABLE XII.

Of the Climates between the Polar Circles and the Poles.

Climates.	Ends in Lat.	Where the longest day is.	Breadths of the Climates.	Climates.	Ends in Lat.	Where the longest day is.	Breadths of the Climates.
	d m.	d. m.	d. m.		d. m.	d. m.	d. m.
25	67 18	30 or 1.	46	28	77 40	120 or 4	4 35
26	69 30	60 2.	2 15	29	82 50	150 5	5 19
27	73 5	90 3.	3 32	30	90 00	180 6	7 1

TABLE XIII.

Showing the Latitude and Longitude of some of the principal places in the United States, &c., with their Distance from the city of Washington.

The Longitudes are reckoned from Greenwich.

The Capitals (seats of Government) of the States and Territories are designated by Italic letters.

		Latitude North.	Longitude, West, in degrees.	Longitude, West, in time.	Dist. from Wash'n.
		° ′ ″	° ′ ″	h.m. s.	miles.
Albany (Capitol),	N. Y.	42 39 3	73 44 49	4 54 59.3	376
Alexandria,	D. C.	38 49	77 4	5 8 16	6
Annapolis,	Md.	39 0	76 43	5 6 52	37
Auburn,	N. Y.	42 55	76 28	5 5 52	339
Augusta,	Ga.	33 28	81 54	5 27 36	580
Augusta (State House),	Me.	44 18 43	69 50	4 39 20	595
Baltimore (Battle Monument),	Md.	39 17 13	76 37 50	5 6 31.3	38
Bangor (Court House),	Me.	44 47 50	68 47	4 35 8	661
Barnstable (Old Court House),	Mass.	41 42 9	70 16	4 41 4	466
Batavia,	N. Y.	42 59	78 13	5 12 52	370
Beaufort,	S. C.	32 25	80 41	5 22 44	629
Boston (State House),	Mass.	42 21 15	71 4 9	4 44 16.6	432
Bristol (Hotel),	R. I.	41 39 58	71 19	4 45 36	409
Brooklyn (Navy Yard),	N. Y.	40 41 50	73 59 30	4 55 58	227
Brunswick (College),	Me.	43 53 0	69 55 1	4 39 40.1	568
Buffalo,	N. Y.	42 53	78 55	5 15 40	376
Cambridge (Harvard Hall),	Mass.	42 22 15	71 7 25	4 44 29.7	431
Camden,	S. C.	34 17	80 30	5 22 12	467
Canandaigua,	N. Y.	42 54	77 17	5 9 8	336
Cape Cod (Light-House),	Mass.	42 2 16	70 4	4 40 16	507
Charleston (College),	S. C.	32 47 0	80 0 52	5 20 3.5	544
Charlestown (Navy Yard),	Mass.	42 22	71 3 33	4 44 14.2	433
Cincinnati,	Ohio.	39 6	84 22	5 37 28	497
Columbia,	S. C.	33 57	81 7	5 24 28	500
Columbus,	Ohio.	39 47	83 3	5 32 12	396
Concord (State House),	N. H.	43 12 29	71 29	4 45 56	474
Dedham (Court House),	Mass.	42 16	71 11	4 44 44	422
Detroit,	Mich.	42 24	82 58	5 31 52	526
Donaldsonville,	La.	30 3	91 2	6 4 8	1278
Dorchester (Ast. Observatory),	Mass.	42 19 15	71 4 15	4 44 17	432
Dover,	Del.	39 10	75 30	5 2 0	114
Dover,	N. H.	43 13	70 54	4 43 36	490
Easton (Court House)	Md.	38 46 10	76 8	5 4 32	80
Eastport,	Me.	44 54	66 56	4 27 44	778
Edenton,	N. C.	36 0	77 7	5 28 28	284
Exeter,	N. H.	42 58	70 55	4 43 40	474
Frankfort,	Ky.	38 14	84 40	5 38 40	551
Fredericksburg,	Va.	38 34	77 38	5 10 32	56
Fredericton,	N. B.	46 3	66 45	4 27 0	
Frederickstown,	Md.	39 24	77 18	5 9 12	43
Georgetown,	S. C.	33 21	79 17	5 17 8	482
Gloucester,	Mass.	42 36	70 40	4 42 40	462
Greensfield,	Mass.	42 37	72 36	4 50 24	396
Hagerstown,	Md.	39 37	77 35	5 10 20	68
Halifax,	N. S.	44 39 20	63 36 40	4 14 27	936

TABLE XIII.—Continued.

		Latitude North.			Longitude, West, in degrees.			Longitude, West, in time.			Dist. from Wash'n
		°	′	″	°	′	″	h.	m.	s.	miles.
Hallowell,	Me.	44	17		69	50		4	39	30	593
Harrisburgh,	Pa.	40	16		76	50		5	7	20	110
Hartford,	Conn.	41	46		72	50		4	51	20	335
Hudson,	N. Y.	42	14		73	46		4	55	4	345
Huntsville,	Ala.	34	36		86	57		5	47	48	726
Indianapolis,	Ind.	39	55		86	5		5	44	20	573
Jackson,	M'pi.	32	23		90	8		6	0	32	1035
Jefferson,	M'ri.	38	36		92	8		6	8	32	980
Kennebunk,	Me.	43	25		70	32		4	42	8	518
Kingston,	U. C.	44	8		76	40		5	6	40	456
Knoxville,	Tenn.	35	59		83	54		5	35	36	516
Lancaster,	Pa.	40	2	36	76	20	33	5	5	22.2	109
Lexington,	Ky.	38	6		84	18		5	37	12	534
Little Rock,	Ark.	34	40		92	12		6	8	48	1068
Lockport,	N. Y.	43	11		78	46		5	15	4	403
Louisville,	Ky.	38	3		85	30		5	42	0	590
Lowell (St. Ann's Church),	Mass.	42	38	45	71	18	45	4	45	15	439
Lynchburgh,	Va.	37	36		79	22		5	17	28	198
Lynn,	Mass.	42	28		70	57		4	43	48	441
Marblehead,	Mass.	42	30		70	52		4	43	28	450
Middletown,	Conn.	41	34		72	39		4	50	36	325
Milledgeville,	Ga.	33	7		83	20		5	33	20	642
Mobile,	Ala.	30	40		88	11		5	52	44	1033
Montpelier,	Vt.	44	17		72	36		4	50	24	524
Monomoy Point Light,	Mass.	41	32	58	70	1	31	4	40	6.1	500
Montreal,	L. C.	45	31		73	35		4	54	20	601
Nantucket (Town Hall),	Mass.	41	16	32	70	7	42	4	40	30.8	500
Nashville,	Tenn.	36	9	30	86	49	3	5	47	16.2	714
Natchez (Castle),	M'pi.	31	34		91	24	42	6	5	38.8	1146
Newark,	N. J.	40	45		74	10		4	56	40	215
New Bedford (Mariners' Ch.),	Mass.	41	38	7	70	56	0	4	43	44	429
Newbern,	N. C.	35	20		77	5		5	8	20	337
Newburgh,	N. Y.	41	31		74	1		4	56	4	282
Newburyport (2d Pres. Ch.),	Mass.	42	48	29	70	52	0	4	43	28	466
Newcastle,	Del.	39	40		75	33		5	2	8	103
New Haven (College),	Conn.	41	17	58	72	57	46	4	51	51.1	301
New London,	Conn.	41	22		72	9		4	48	36	354
New Orleans (City),	La.	29	57	45	90	6	49	6	0	27.3	1203
Newport,	R. I.	41	29		71	21	14	4	45	24.9	403
New York (City Hall),	N. Y.	40	42	40	74	1	8	4	56	4.5	226
Norfolk (Farmer's Bank),	Va.	36	50	50	76	18	47	5	5	15.1	217
Northampton (Mansion House),	Mass.	42	18	55	72	40		4	50	40	376
Norwich,	Conn.	41	33		72	7		4	48	28	362
Pensacola,	Fa.	30	28		87	12		5	48	48	1050
Petersburgh,	Va.	37	13	54	77	20		5	9	20	144
Philadelphia (Independence H.),	Pa.	39	56	59	75	10	59	5	0	43.9	136
Pittsburgh,	Pa.	40	32		30	8		5	20	32	223
Pittsfield, (1st Cong. Church),	Mass.	42	26	59	73	17	30	4	53	10	380
Plattsburgh,	N. Y.	44	42		73	26		4	53	44	539
Plymouth (Court House),	Mass.	41	57	12	70	42	30	4	42	50	439
Portland (Town House),	Me.	43	39	26	70	20	30	4	41	22	542
Portsmouth (Court House),	N. H.	43	4	54	70	45		4	43	0	491
Poughkeepsie,	N. Y.	41	41		73	55		4	55	40	301
Princeton,	N. J.	40	22		74	35		4	58	20	177

TABLE XIII.—Continued.

		Latitude North.	Longitude, West, in degrees.	Longitude, West, in time.	Dist. from Wash'n.
		° ′ ″	° ′ ″	h. m. s.	miles.
Providence (Old Col.),	R. I.	41 49 25	71 25 56	4 45 43.7	394
Quebec (Castle),	L. C.	46 47 17	70 56 31	4 43 46.1	781
Raleigh,	N. C.	35 47	78 48	5 15 12	286
Richmond (Capitol),	Va.	37 32 17	77 26 28	5 9 49.9	122
Rochester (R'r House),	N. Y.	43 8 17	77 51	5 11 24	361
Sable (Cape),	Fa.	24 50	81 15	5 25 0	
Sackett's Harbour,	N. Y.	43 55	75 57	5 3 48	407
Saco,	Me.	43 31	70 26	4 41 44	528
St. Augustine,	Fa.	29 48 30	81 35	5 26 20	841
St. Louis,	M'ri.	38 36	89 36	5 58 24	856
Salem (E. I. M. Hall),	Mass.	42 31 19	70 54	4 43 36	446
Savannah,	Ga.	32 2	81 3	5 24 12	662
Schenectady,	N. Y.	42 48	73 55	4 55 40	391
Springfield (Court House),	Mass.	42 5 58	72 36	4 50 24	357
Tallahassee,	Fa.	30 28	84 36	5 38 24	896
Taunton (Court House),	Mass.	41 54 9	71 50	4 44 20	415
Toronto (York),	U. C.	43 33	79 20	5 17 20	500
Trenton,	N. J.	40 14	74 39	4 58 36	166
Troy,	N. Y.	42 44	73 40	4 54 40	382
Tuscaloosa,	Ala.	33 12	87 42	5 50 48	858
University of Virginia,	Va.	38 2 3	78 31 29	5 14 5.9	124
Utica (Dutch Church),	N. Y.	43 6 49	75 13	5 0 52	383
Vandalia,	Il.	38 50	89 2	5 56 8	781
Vevay,	Ind.	38 46	84 59	5 39 56	556
Vincennes,	Ind.	38 43	87 25	5 49 40	1693
WASHINGTON, (Capitol),	D. C.	38 52 54	77 1 48	5 8 7.2	–
Washington,	M'pi.	31 36	91 20	6 5 20	146
Wheeling,	Va.	40 7	80 42	5 22 48	264
Wilmington,	Del.	39 41	75 28	5 1 52	108
Wilmington,	N. C.	34 11	78 10	5 12 40	416
Worcester (Ant. Hall),	Mass.	42 16 9	71 49 0	4 47 16	394
York,	Me.	43 10	70 40	4 42 40	500
York,	Pa.	39 58	76 40	5 6 40	87